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Okimoto et al.

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(45) **Date of Patent: Jul. 14, 2015**

(54) **AUDIO SIGNAL PROCESSING DEVICE, AUDIO SIGNAL PROCESSING METHOD, AND PROGRAM**

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(73) Assignee: **Sony Corporation**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 882 days.

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(30) **Foreign Application Priority Data**

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(51) **Int. Cl.**
G06F 17/00 (2006.01)
H04S 7/00 (2006.01)

(52) **U.S. Cl.**
CPC ***H04S 7/301*** (2013.01); ***H04S 7/302*** (2013.01); *H04R 2499/13* (2013.01); *H04R 2499/15* (2013.01); *H04S 7/305* (2013.01)

(58) **Field of Classification Search**
CPC H04R 3/04; H04R 2205/024; H04S 7/301; H04S 7/302; H04S 7/305
USPC 700/94
See application file for complete search history.

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* cited by examiner

Primary Examiner — Joseph Saunders, Jr.
(74) *Attorney, Agent, or Firm* — Sherr & Jiang, PLLC

(57) **ABSTRACT**

An audio signal processing device includes two audio signal processing units that serially perform a processing with respect to an input audio signal, and obtain an output audio signal for driving a speaker. One audio signal processing unit of the two audio signal processing units performs, with respect to the input audio signal, a correction process through a filter that realizes a reverse characteristic of an impulse response measured at a first measurement position that is a front position of the speaker. The other audio signal processing unit performs, with respect to the input audio signal, a correction process through a filter that realizes a reverse characteristic of an impulse response measured at a second measurement position different from the first measurement position that is a front position of the speaker.

12 Claims, 19 Drawing Sheets

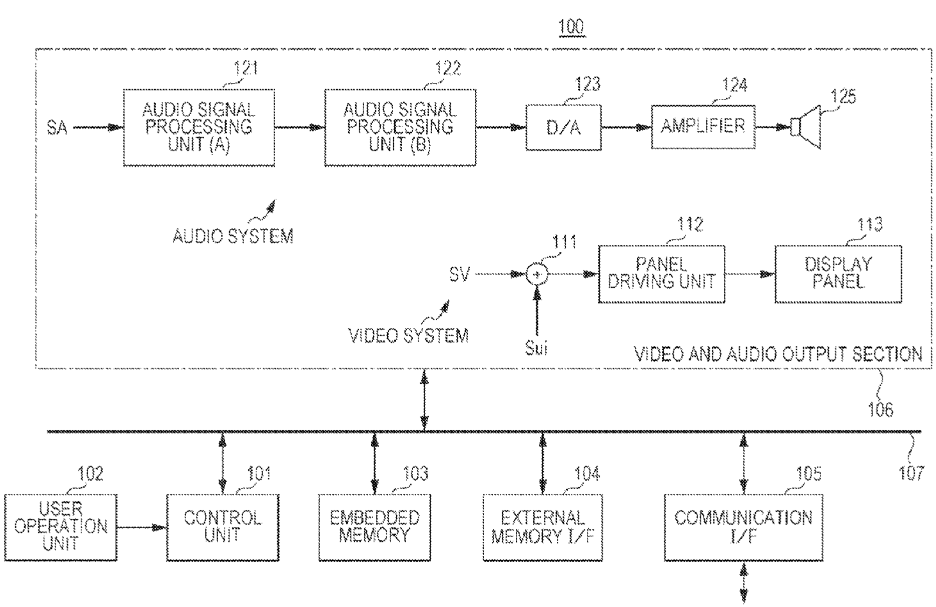


FIG. 1

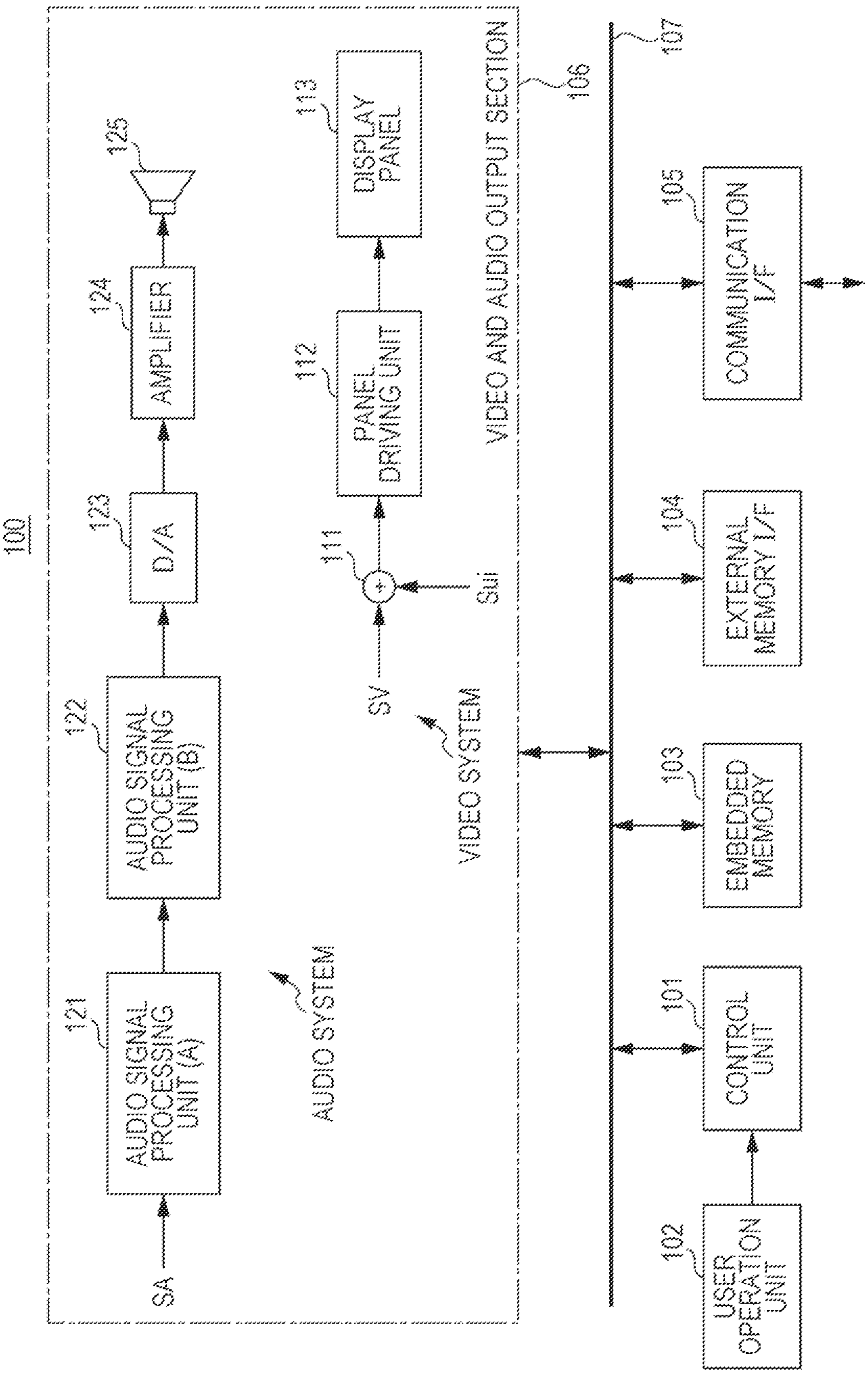

100
SA
AUDIO SIGNAL PROCESSING UNIT (A)
121
AUDIO SYSTEM
AUDIO SIGNAL PROCESSING UNIT (B)
122
D/A
123
AMPLIFIER
124
125
SV
111
Sui
PANEL DRIVING UNIT
112
DISPLAY PANEL
113
VIDEO SYSTEM
VIDEO AND AUDIO OUTPUT SECTION
106
107
USER OPERATION UNIT
102
CONTROL UNIT
101
EMBEDDED MEMORY
103
EXTERNAL MEMORY I/F
104
COMMUNICATION I/F
105

FIG. 2

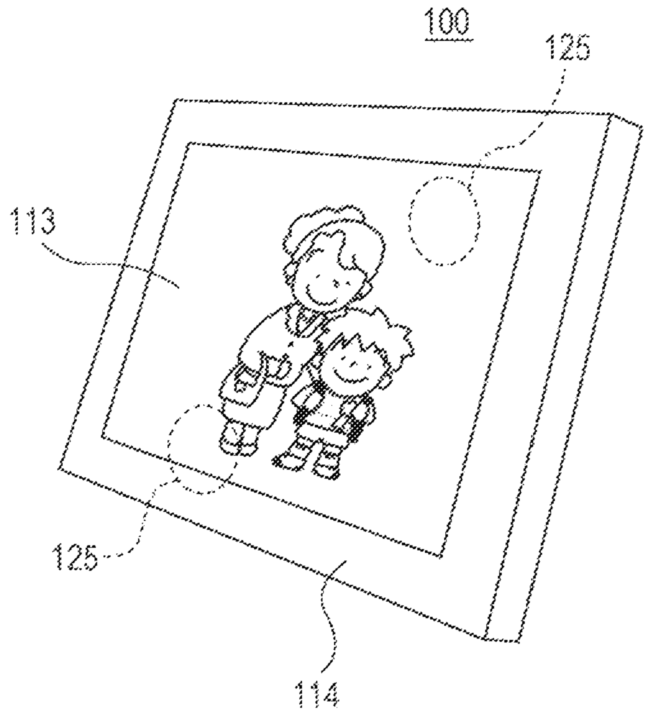

100
125
113
125
114

FIG. 3

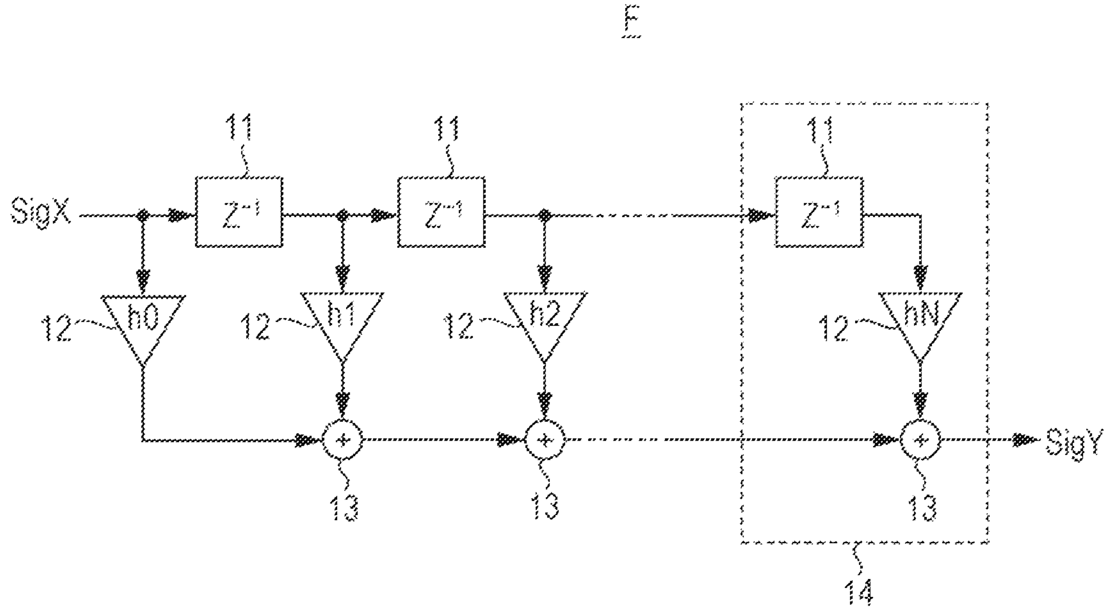
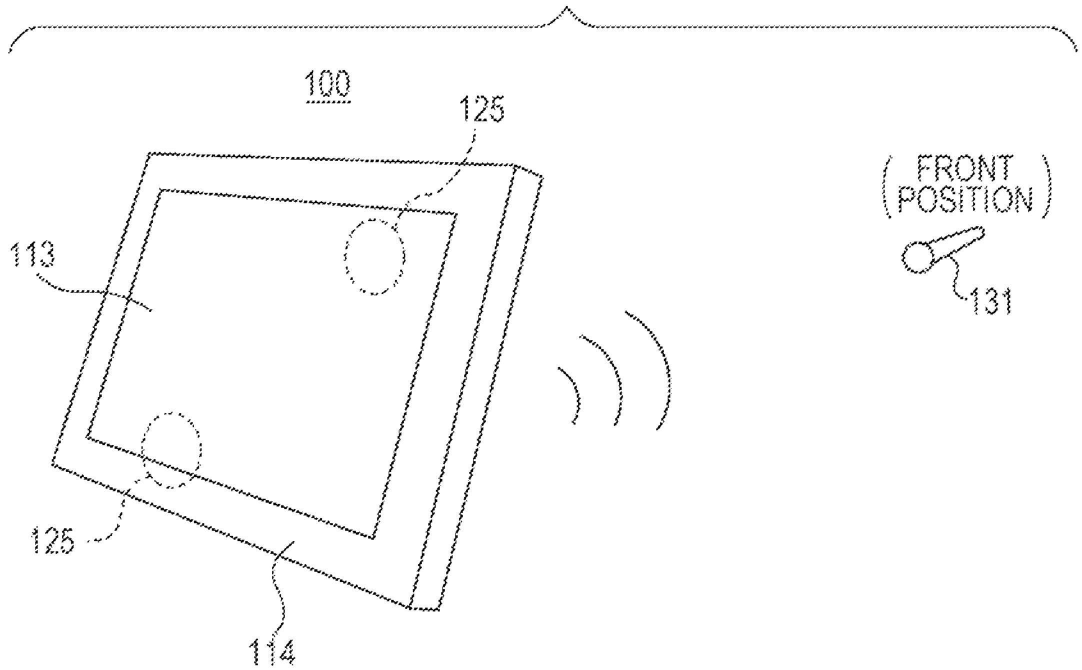
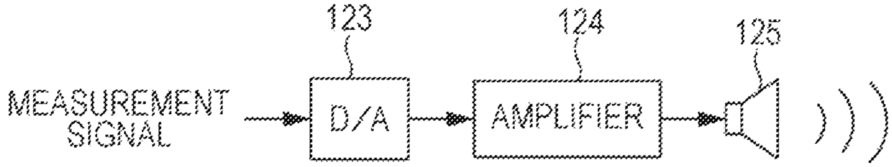

F
11
11
11
SigX
Z⁻¹
Z⁻¹
Z⁻¹
12
h0
12
h1
12
h2
12
hN
13
13
13
SigY
14

FIG. 4



100
125
113
125
114
FRONT POSITION
131

FIG. 5



MEASUREMENT SIGNAL
123
D/A
124
AMPLIFIER
125

FIG. 6A

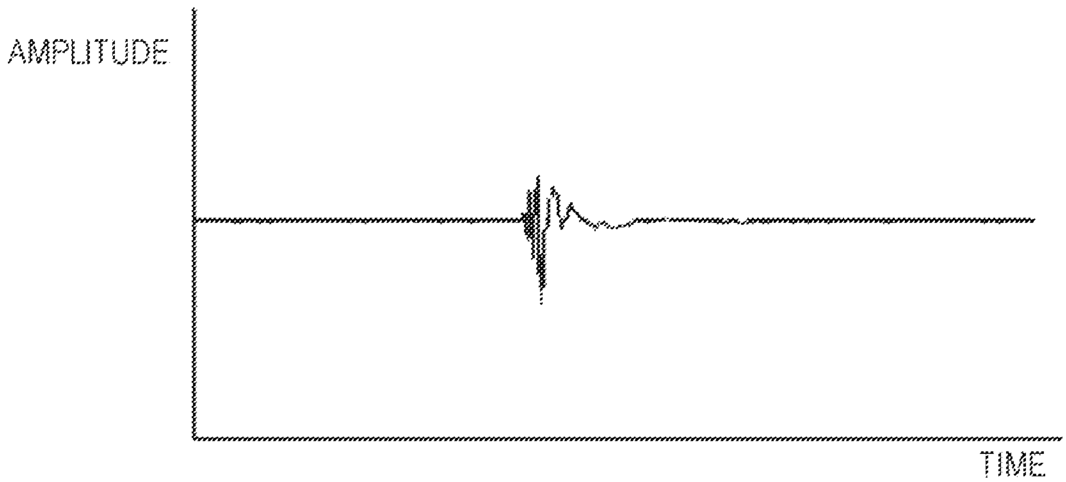


FIG. 6B

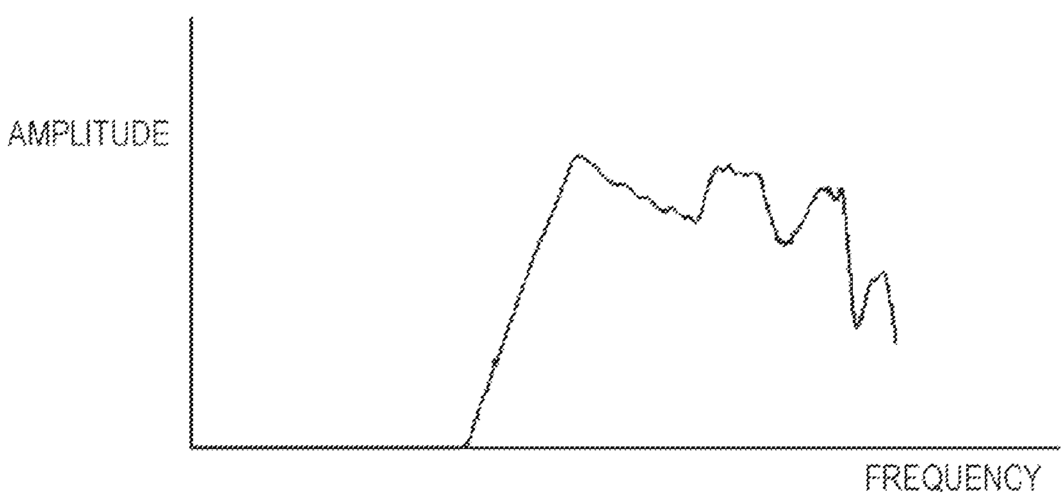


FIG. 7A

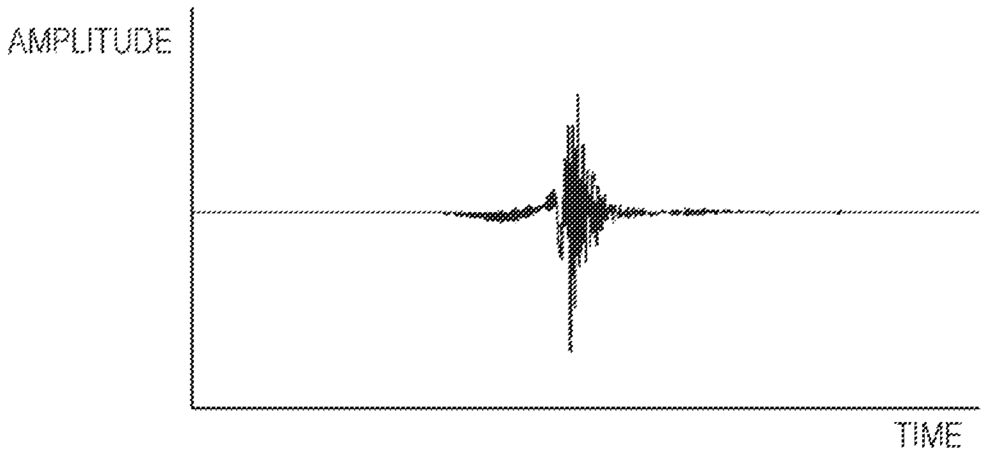


FIG. 7B

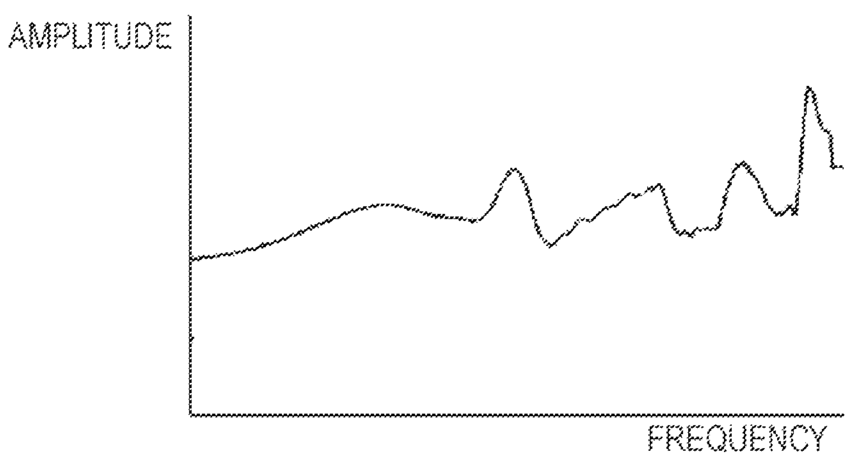


FIG. 8A

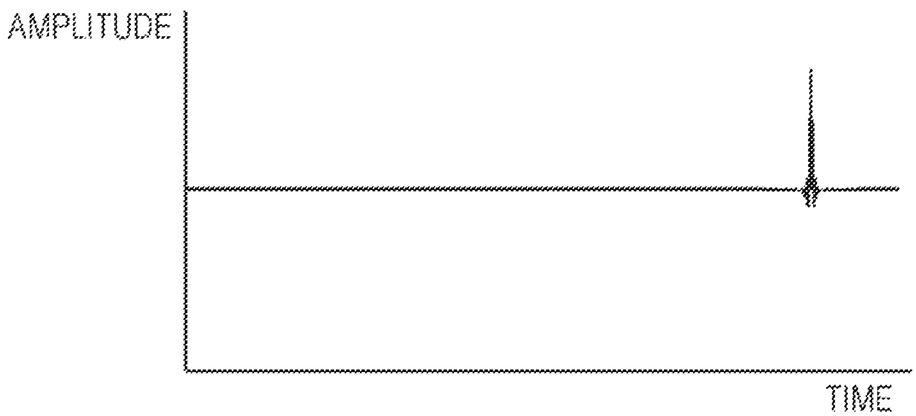


FIG. 8B

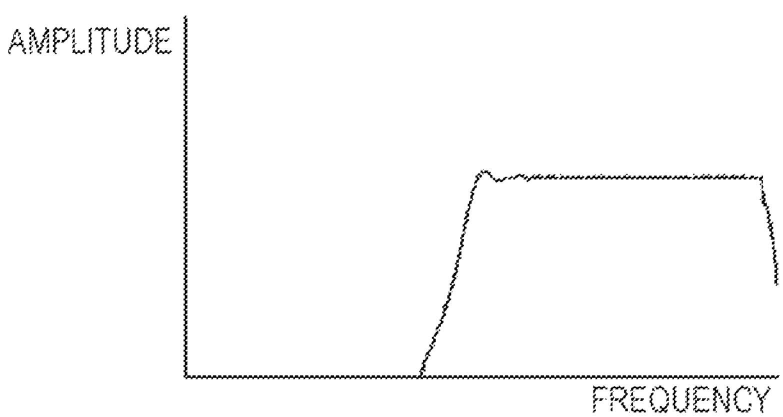


FIG. 9

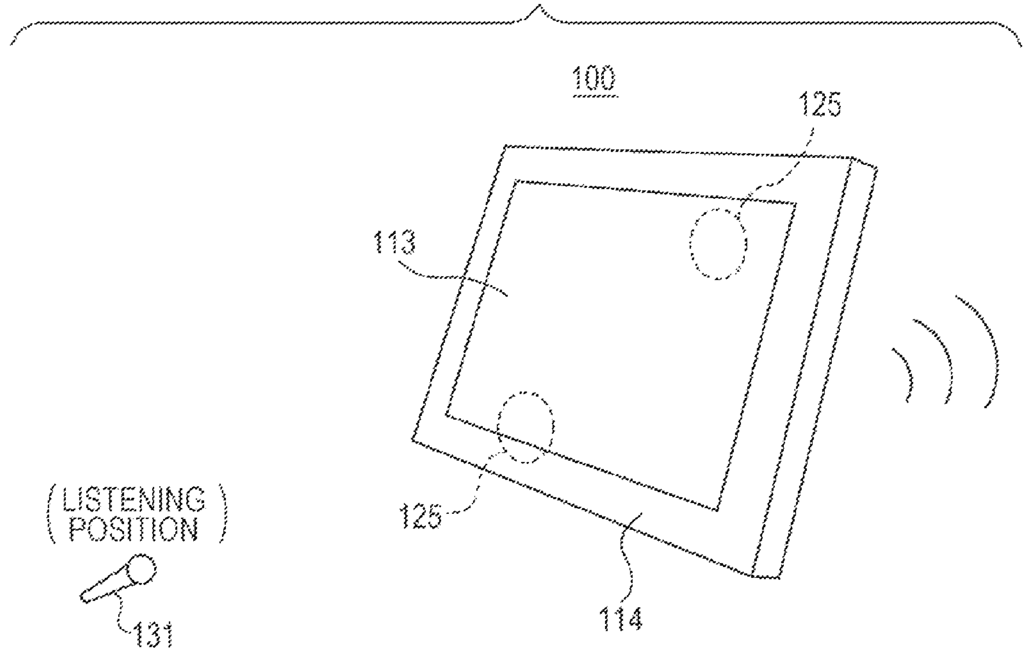

100
125
113
125
(LISTENING POSITION)
131
114

FIG. 10

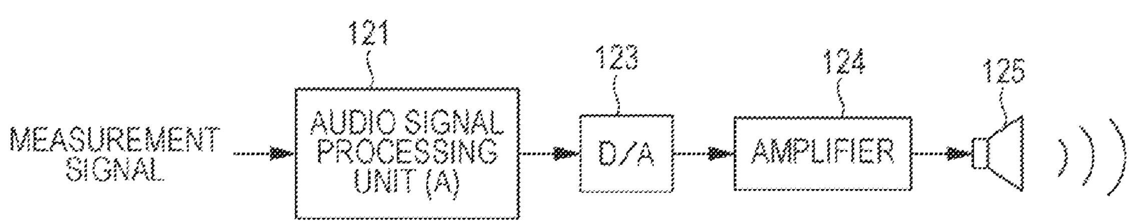

121
123
124
125
MEASUREMENT SIGNAL
AUDIO SIGNAL PROCESSING UNIT (A)
D/A
AMPLIFIER

FIG. 11A

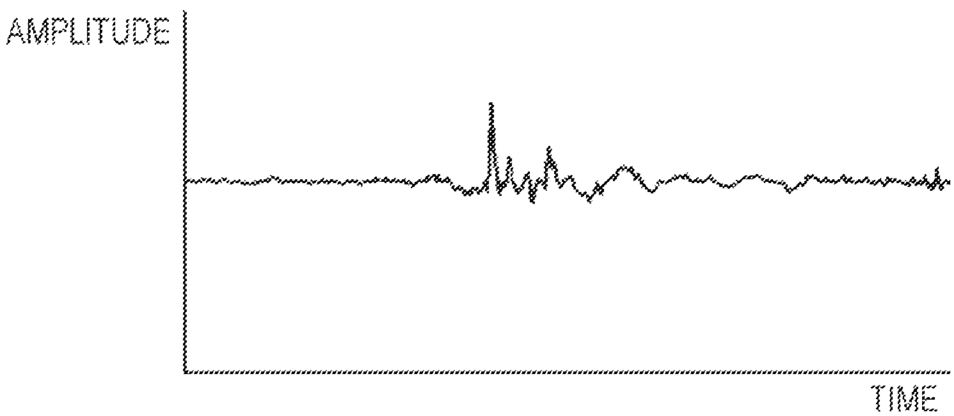


FIG. 11B

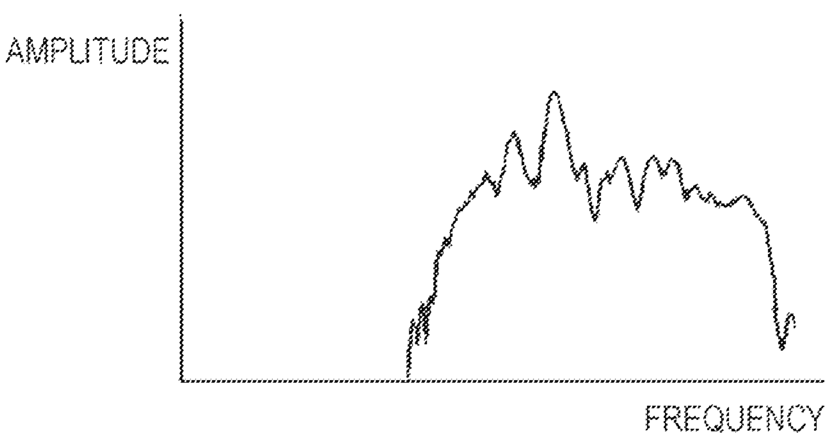


FIG. 12A

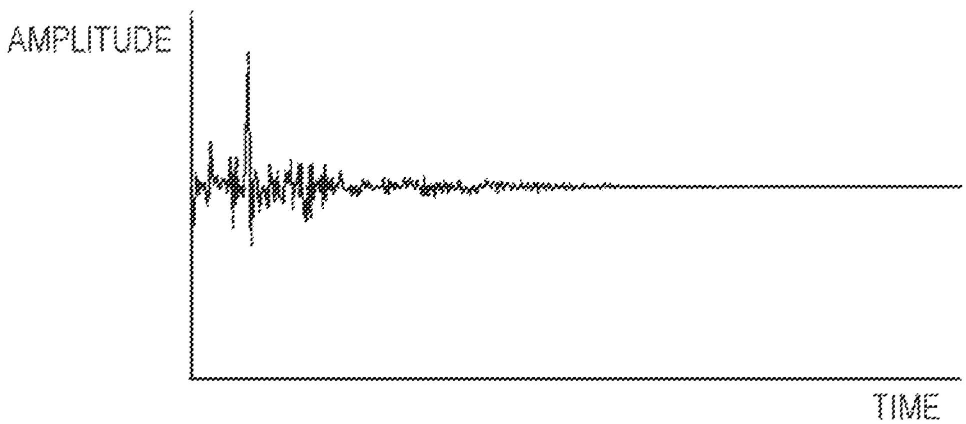


FIG. 12B

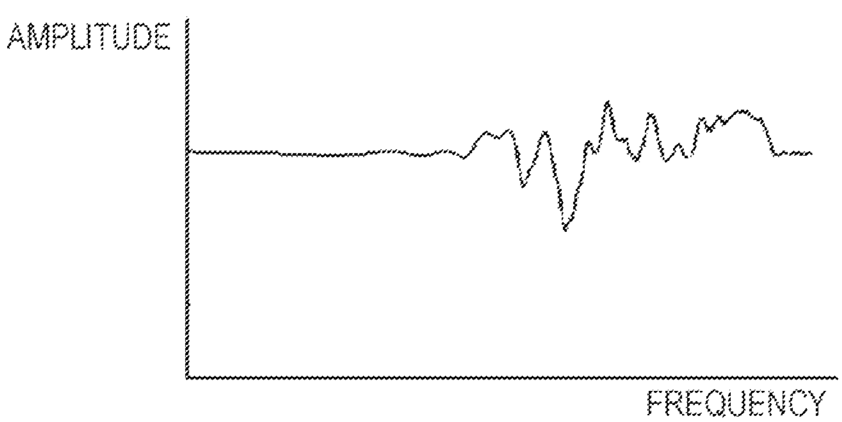


FIG. 13A

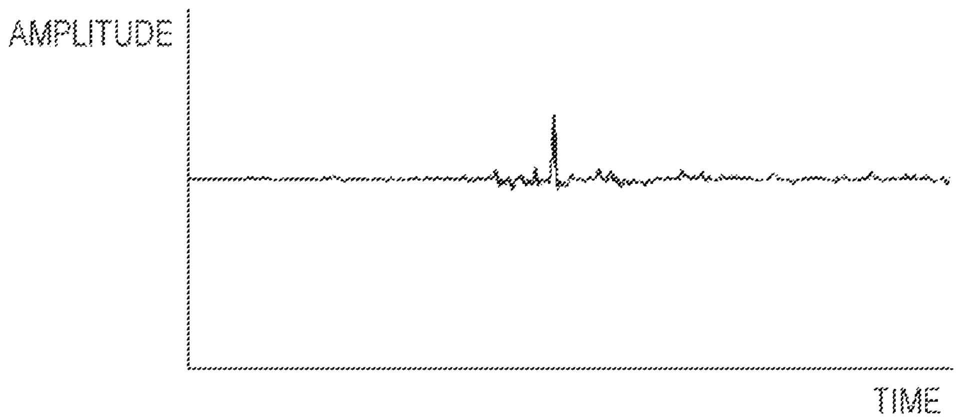


FIG. 13B

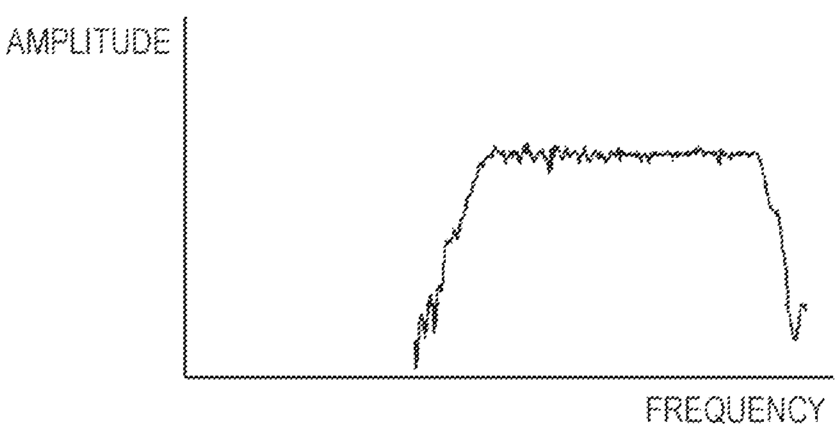


FIG. 14

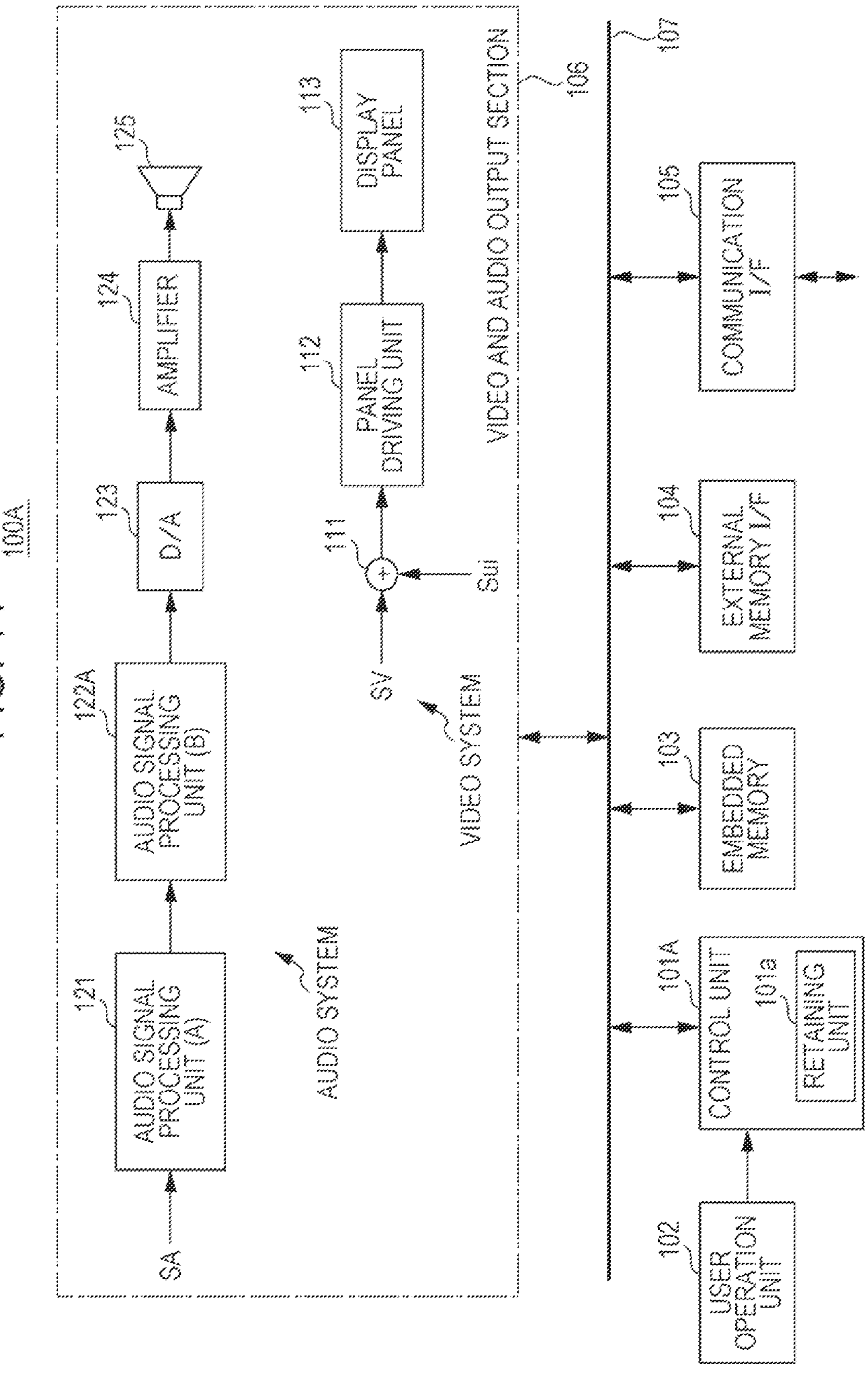

100A
SA
121
AUDIO SIGNAL PROCESSING UNIT (A)
122A
AUDIO SIGNAL PROCESSING UNIT (B)
123
D/A
124
AMPLIFIER
125
AUDIO SYSTEM
SV
111
Sui
112
PANEL DRIVING UNIT
113
DISPLAY PANEL
VIDEO SYSTEM
VIDEO AND AUDIO OUTPUT SECTION
106
107
102
USER OPERATION UNIT
101A
CONTROL UNIT
101a
RETAINING UNIT
103
EMBEDDED MEMORY
104
EXTERNAL MEMORY I/F
105
COMMUNICATION I/F

FIG. 15

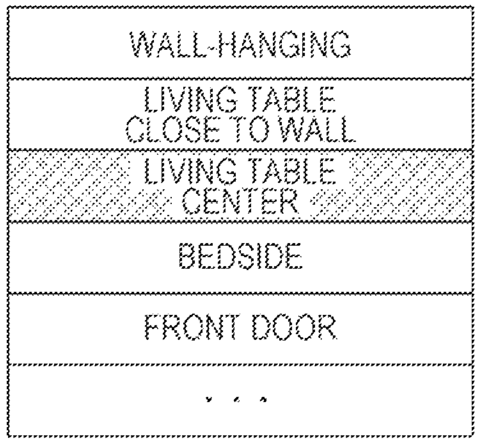

WALL-HANGING
LIVING TABLE CLOSE TO WALL
LIVING TABLE CENTER
BEDSIDE
FRONT DOOR
. . .

FIG. 16

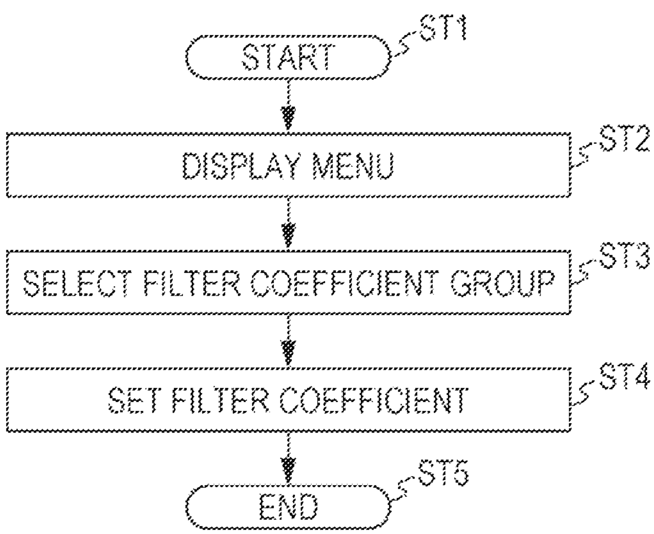

START
ST1
DISPLAY MENU
ST2
SELECT FILTER COEFFICIENT GROUP
ST3
SET FILTER COEFFICIENT
ST4
END
ST5

FIG. 17

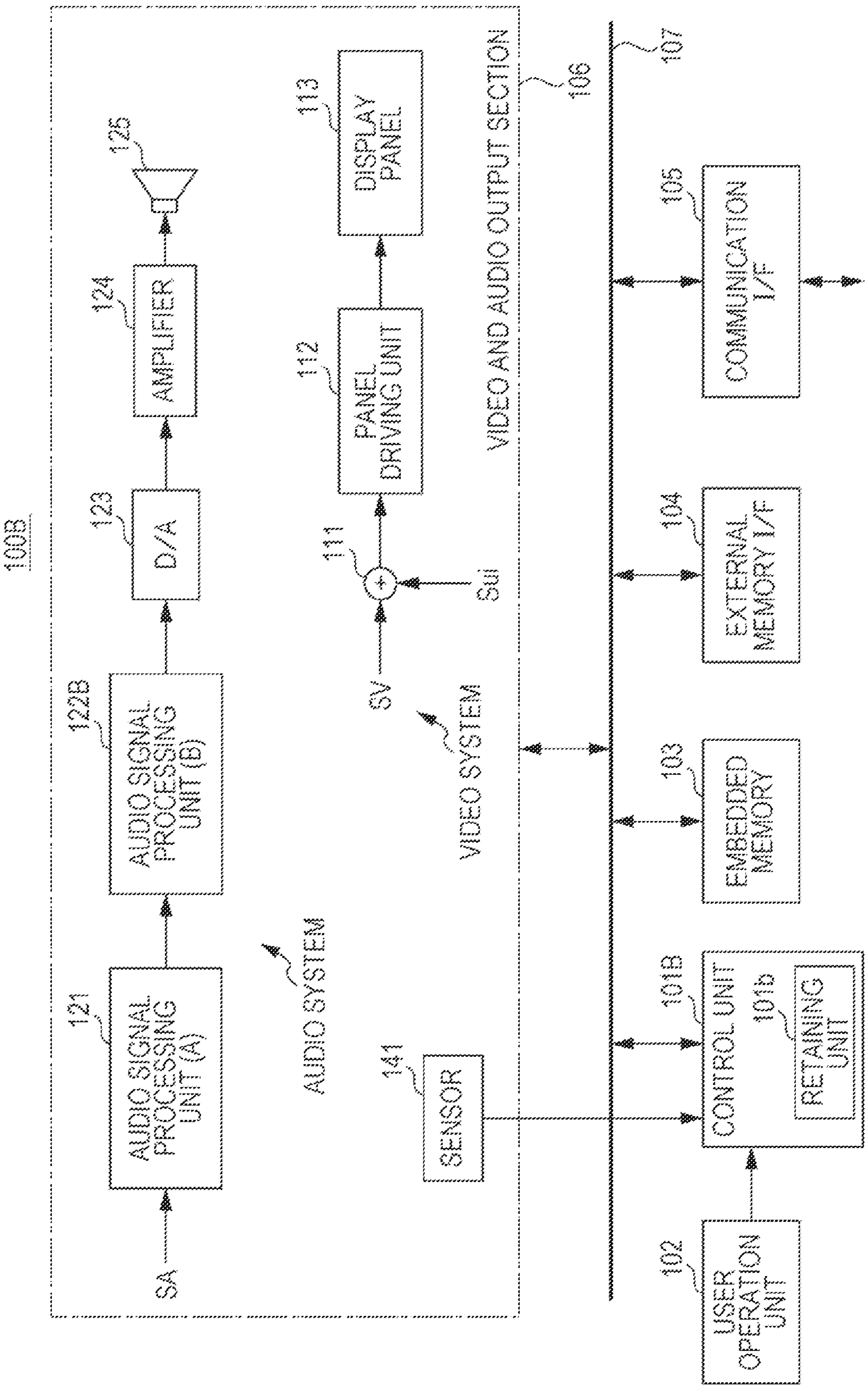

100B
SA
AUDIO SIGNAL PROCESSING UNIT (A)
121
AUDIO SIGNAL PROCESSING UNIT (B)
122B
D/A
123
AMPLIFIER
124
125
AUDIO SYSTEM
VIDEO SYSTEM
SV
111
Sui
PANEL DRIVING UNIT
112
DISPLAY PANEL
113
VIDEO AND AUDIO OUTPUT SECTION
106
107
SENSOR
141
USER OPERATION UNIT
102
CONTROL UNIT
101B
RETAINING UNIT
101b
EMBEDDED MEMORY
103
EXTERNAL MEMORY I/F
104
COMMUNICATION I/F
105

FIG. 18A

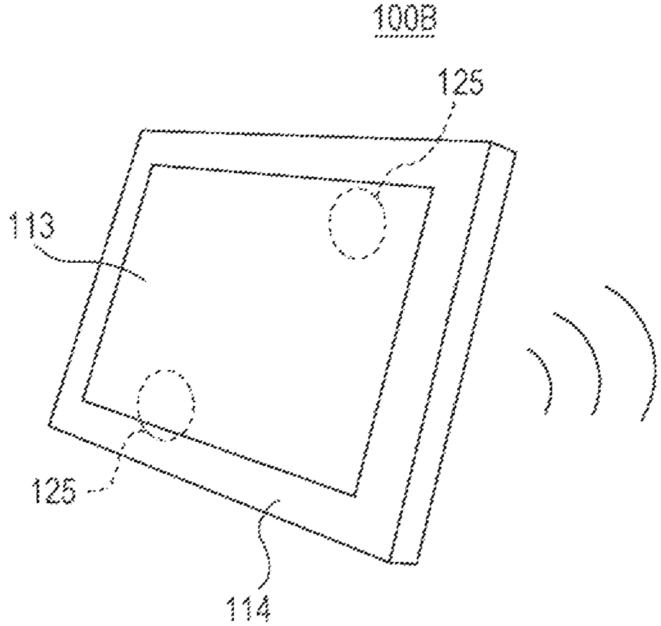


FIG. 18B

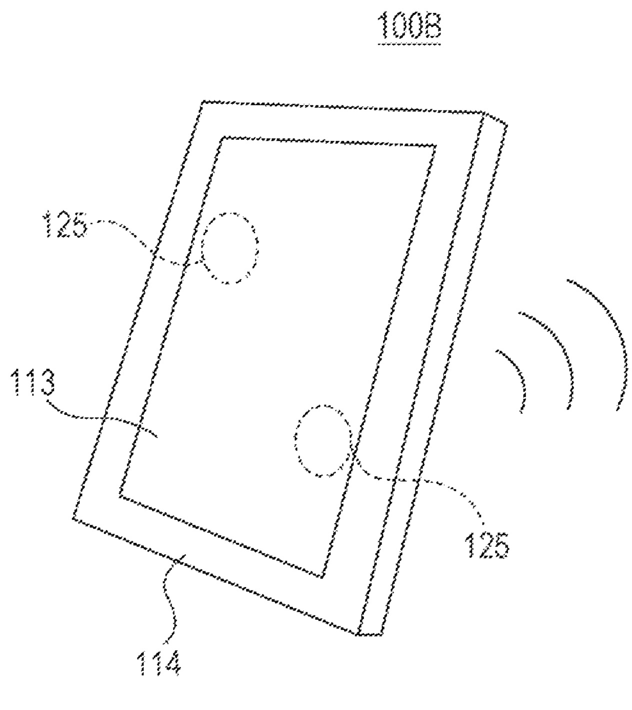


FIG. 19

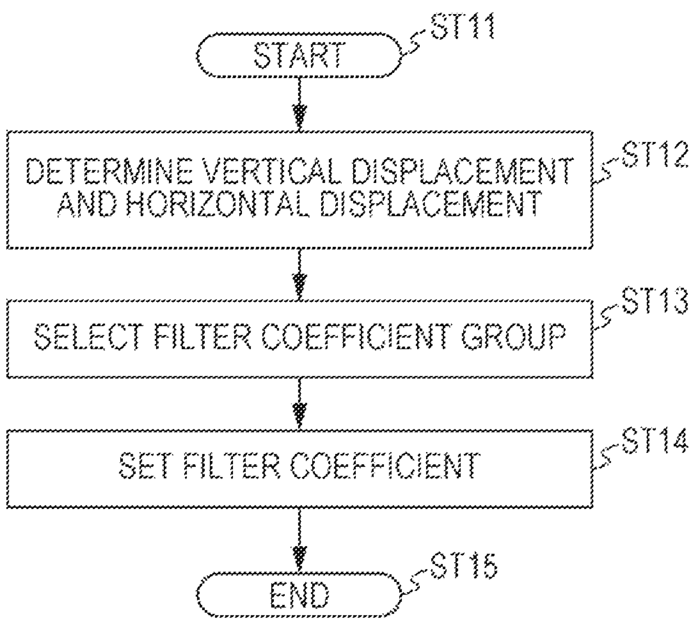

START
ST11
DETERMINE VERTICAL DISPLACEMENT AND HORIZONTAL DISPLACEMENT
ST12
SELECT FILTER COEFFICIENT GROUP
ST13
SET FILTER COEFFICIENT
ST14
END
ST15

FIG. 20

200

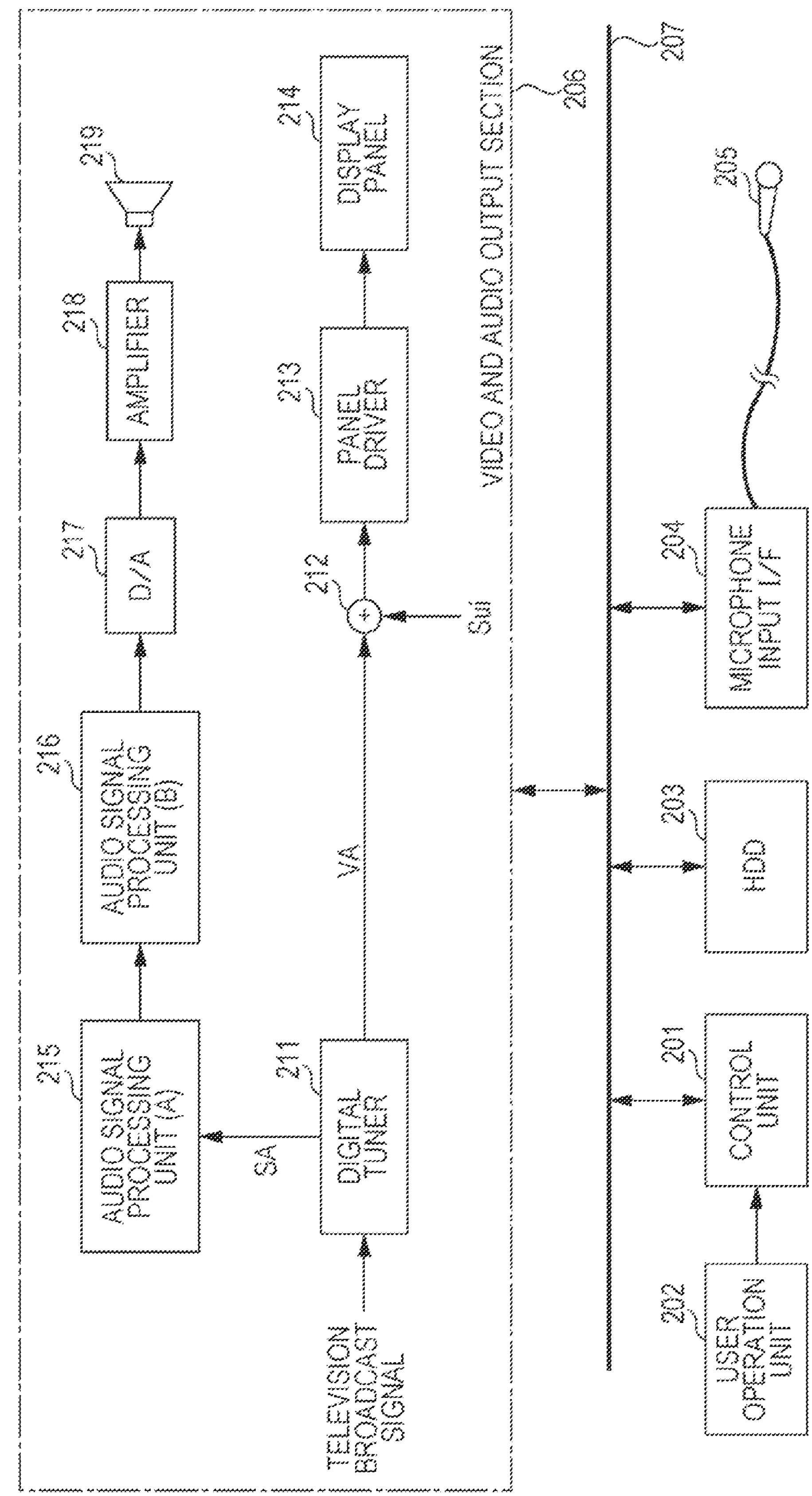

TELEVISION BROADCAST SIGNAL
DIGITAL TUNER
211
SA
VA
AUDIO SIGNAL PROCESSING UNIT (A)
215
AUDIO SIGNAL PROCESSING UNIT (B)
216
D/A
217
AMPLIFIER
218
219
212
Sui
PANEL DRIVER
213
DISPLAY PANEL
214
VIDEO AND AUDIO OUTPUT SECTION
206
207
USER OPERATION UNIT
202
CONTROL UNIT
201
HDD
203
MICROPHONE INPUT I/F
204
205

FIG. 21

200

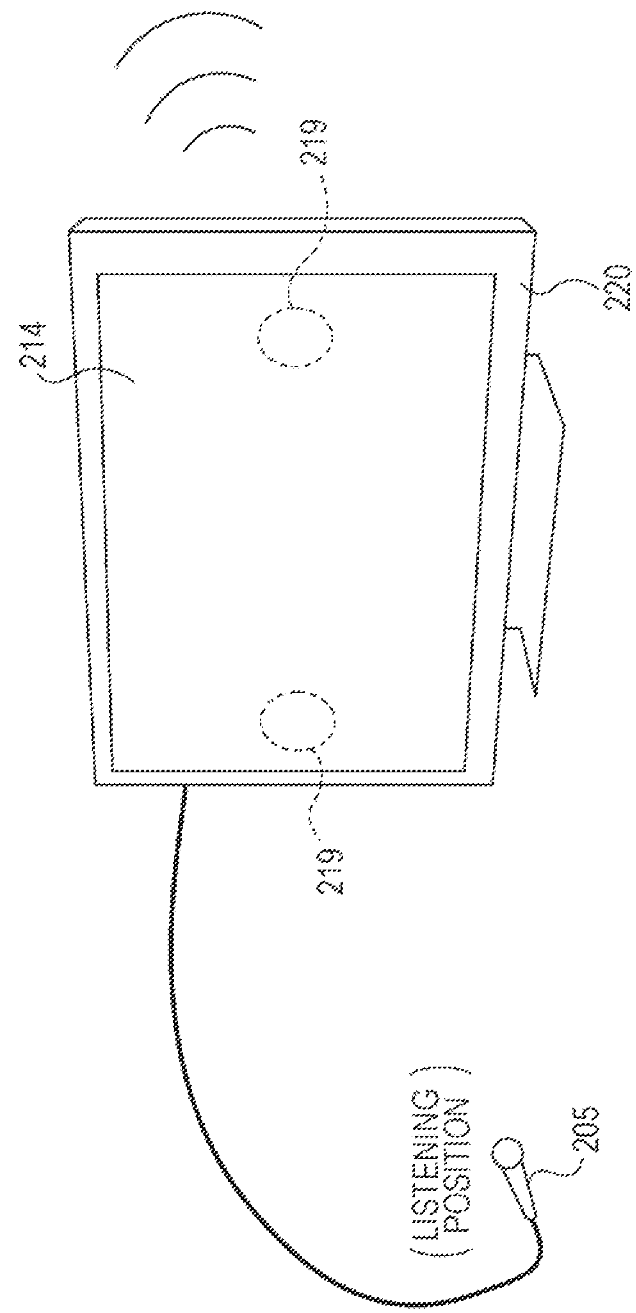


FIG. 22

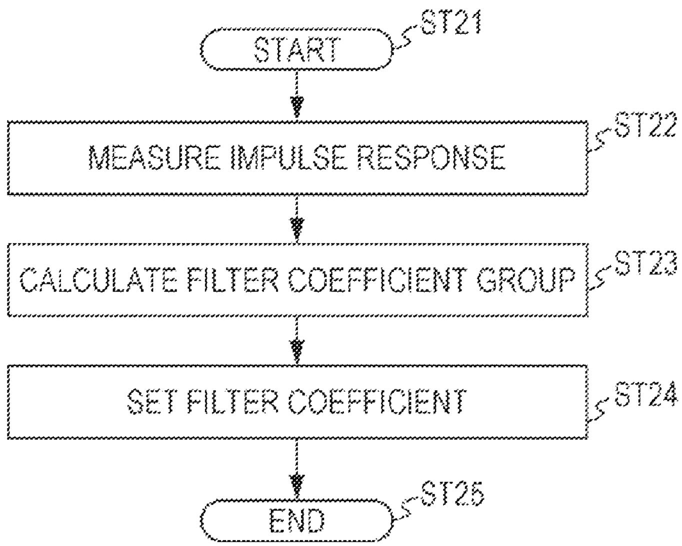

START
ST21
MEASURE IMPULSE RESPONSE
ST22
CALCULATE FILTER COEFFICIENT GROUP
ST23
SET FILTER COEFFICIENT
ST24
END
ST25

FIG. 23

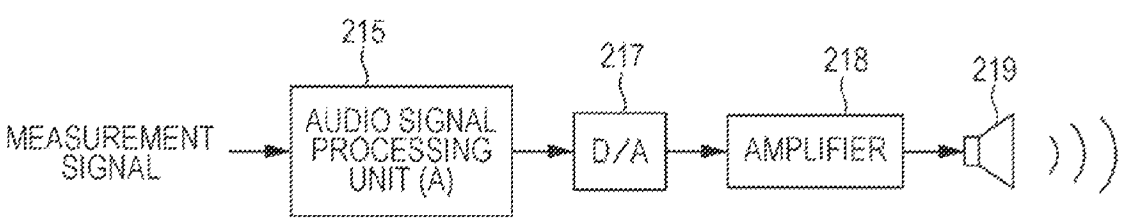
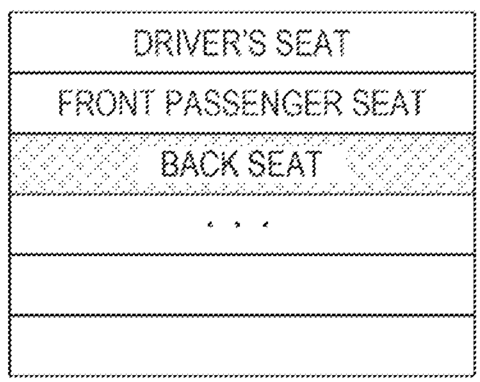

MEASUREMENT SIGNAL
215
AUDIO SIGNAL PROCESSING UNIT (A)
217
D/A
218
AMPLIFIER
219

FIG. 24



AUDIO SIGNAL PROCESSING DEVICE, AUDIO SIGNAL PROCESSING METHOD, AND PROGRAM

BACKGROUND

The present disclosure relates to an audio signal processing device, an audio signal processing method, and a program, and more particularly, to an audio signal processing device that obtains an audio signal for driving a speaker, or the like.

In regard to an apparatus such as a piece of acoustic equipment that performs an audio signal processing (hereinafter, referred to as an audio signal processing apparatus), there is disclosed a technique that performs a correction process such as a digital filtering process with respect to an audio signal acquired from an audio source. The audio signal processing apparatus outputs an audio signal subjected to the correction process from a speaker or the like, such that it is possible to improve an acoustic quality, acoustic effect, or the like of audio that is output from the speaker or the like.

As one such correction process, correction of a speaker characteristic may be exemplified. The speaker characteristic represents a frequency characteristic of a speaker, which is different depending on an aperture of the speaker, an internal structure, or the like. Here, the frequency characteristic of a speaker includes a phase characteristic that is a temporal variation between the audio signal input to the speaker and the audio signal output from the speaker, an amplitude characteristic that is a strength ratio, or the like.

As an audio signal processing apparatus that can correct the speaker characteristic by performing the correction process with respect to the audio signal, for example, a signal processing device disclosed in Japanese Unexamined Patent Application Publication 2009-55079 may be exemplified. This signal processing device is for promoting an improvement in a low band component of a small-sized speaker by combining an amplification of a low frequency band signal of an input audio signal, and a shift to a high frequency band.

SUMMARY

In regard to a speaker system, a technique, which realizes high acoustic quality through an inverse filtering process, is disclosed. However, there is a problem in that in an audio reproducing system in which a speaker is not installed in a front direction, a listening position characteristic is not optimized, and thereby sufficient high acoustic quality is not obtained.

In recent years, the mounting location of the speaker has varied according to thickness reduction and miniaturization of a product. Particularly, in a design where a design is considered to be important, an invisible speaker design where a speaker is made to be invisible from the outside has become mainstream, and the number of a speaker product, which faces a front side of a product similar to a product until now, has been reduced.

In regard to such a product, even when a speaker high acoustic quality process is performed through an inverse filtering process in the related art, characteristics at a position where a user actually uses a product, and a listening position are not optimized, and therefore an expected effect is not obtained.

It is desirable to provide an audio signal processing device or the like that can provide high acoustic quality with respect to an audio reproducing system in which a speaker is not disposed in a front direction.

According to an embodiment of the present disclosure, there is provided an audio signal processing device including two audio signal processing units that serially perform a processing with respect to an input audio signal, and obtain an output audio signal for driving a speaker, wherein one audio signal processing unit of the two audio signal processing units performs, with respect to the input audio signal, a correction process through a filter that realizes a reverse characteristic of an impulse response measured at a first measurement position that is a front position of the speaker, and the other audio signal processing unit performs, with respect to the input audio signal, a correction process through a filter that realizes a reverse characteristic of an impulse response measured at a second measurement position different from the first measurement position that is a front position of the speaker.

According to this embodiment, by two audio signal processing units, a serial processing is performed with respect to an input audio signal, and an output audio signal for driving a speaker is obtained. One audio signal processing unit of the two audio signal processing units performs, with respect to the input audio signal, a correction process through a filter that realizes a reverse characteristic of an impulse response measured at a first measurement position that is a front position of the speaker. In addition, the other audio signal processing unit performs, with respect to the input audio signal, a correction process through a filter that realizes a reverse characteristic of an impulse response measured at a second measurement position different from the first measurement position that is a front position of the speaker.

As described above, according to the embodiment of the present disclosure, through the correction process in one audio signal processing unit, it is possible to correct disturbance at an inherent sound pressure-frequency characteristic or a phase characteristic which a speaker has. In addition, through the correction process of the other audio signal processing unit, it is possible to correct disturbance in a sound pressure-frequency characteristic or a phase characteristic, which are caused due to a fact that a listening position becomes different from a front position of the speaker. Therefore, it is possible to realize high acoustic quality with respect to a system in which the speaker is not disposed in a front direction.

In addition, the audio processing device may further include, for example, a filter coefficient group retaining unit that retains a plurality of filter coefficient groups as a filter coefficient group of the filter of the other audio signal processing unit; a filter coefficient group selecting unit that selects an arbitrary filter coefficient group among the plurality of filter coefficient groups retained in the filter coefficient group retaining unit; and a filter coefficient setting unit that sets the filter coefficient group selected in the filter coefficient group selecting unit to the filter of the other audio signal processing unit.

For example, the plurality of filter coefficient groups retained in the filter coefficient group retaining unit may be a plurality of filter coefficient groups corresponding to an installation state of the speaker. The installation state of the speaker may include, for example, a state where an audio reproducing system (a photo frame or the like) including the speaker is hung on a wall, a state where the audio reproducing system is on a living room table (close to a wall), a state where the audio reproducing system is on a living room table (center), a state where the audio reproducing system is at a side of a bed, a state where the audio reproducing system is in an entrance hall, or the like.

In addition, the plurality of filter coefficient groups retained in the filter coefficient group retaining unit may be a plurality of filter coefficient groups corresponding to a listening position. For example, in an in-vehicle audio reproducing system including a speaker, the listening position may be a driver's seat, a front passenger seat, a back seat, or the like.

Disturbance in the sound pressure-frequency characteristic or the phase characteristic at the listening position varies depending on the installation state of the speaker or the listening position itself. When a plurality of filter coefficient groups corresponding to the installation state of the speaker, or the listening position is retained and is selectively set to the filter of the other audio signal processing unit, it is possible to realize high acoustic quality regardless of the installation state or the listening position of the speaker.

In addition, the speaker may be disposed integrally with a display panel that performs a video display, and the audio signal processing device may further include: a filter coefficient group retaining unit that retains a plurality of filter coefficient groups corresponding to an installation angle of the display panel as the filter coefficient group of the other audio signal processing unit; an installation angle detecting unit that detects the installation angle of the display panel; and a filter coefficient setting unit that fetches the filter coefficient group corresponding to the installation angle of the display panel from the plurality of filter coefficient groups that is retained in the filter coefficient group retaining unit, based on a detection output of the installation angle detecting unit, and sets it to the filter of the other audio signal processing unit.

For example, in the case of a display panel making up a digital photo frame, or the like, there may be two installation angles in a case where the display panel is disposed with a horizontal displacement and in a case where the display panel is disposed with a vertical displacement. In addition, for example, in the case of a display panel making up a video camera, as the installation angle thereof, there may be a plurality of installation angles corresponding to an aperture angle of the display panel with respect to the video camera main body.

Due to the installation angle of the display panel, disturbance in the sound pressure-frequency characteristic or the phase characteristic at a listening position varies. When a plurality of filter coefficient groups corresponding to an installation angle of the display panel is retained and a filter coefficient group corresponding to an installation angle of a display panel is automatically set to the filter of the other audio signal processing unit, it is possible to realize high acoustic quality regardless of the installation angle of the display panel or the like.

In addition, the audio signal processing device may further include: for example, an impulse response measuring unit that measures the impulse response at the second measurement position; a filter coefficient group calculating unit that calculates the filter coefficient group of the filter that realizes a reverse characteristic of the impulse response measured in the impulse response measuring unit; and a filter coefficient setting unit that sets the filter coefficient group calculated in the filter coefficient group calculating unit to the filter of the other audio signal processing unit.

In this case, the filter coefficient group of the filter, which realizes the reverse characteristic of the impulse response measured at the second measurement position, may be calculated, and this filter coefficient group may be set to the filter of the other audio signal processing unit. Therefore, when the second measurement position is set as a listening position (listening point), it is possible to reliably correct disturbance in the sound pressure-frequency characteristic or the phase characteristic in regard to the listening position. That is, it is possible to realize high acoustic quality regardless of a real use environment of a user.

According to the embodiment of the present disclosure, it is possible to realize high acoustic quality with respect to an audio reproducing system in which a speaker is not disposed in a front direction, such that it is possible to realize a natural reproduction sound and a clear localization of sound by a faithful reproduction of the original sound.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram illustrating a configuration example of a digital photo frame according to a first embodiment of the present disclosure;

FIG. **2** is a diagram illustrating an exterior appearance of the digital photo frame;

FIG. **3** is a diagram illustrating a configuration example of a digital filter that is used as an audio signal processing unit;

FIG. **4** is a diagram illustrating an impulse response measurement when a filter coefficient group is obtained in the audio signal processing unit to correct a speaker characteristic of a speaker;

FIG. **5** is a diagram illustrating a configuration of an audio system when the filter coefficient group is obtained in the audio signal processing unit to correct the speaker characteristic of the speaker;

FIGS. **6**A and **6**B are diagrams illustrating an example of an impulse response measured at a front position of the speaker and an amplitude-frequency characteristic corresponding thereto;

FIGS. **7**A and **7**B are diagrams illustrating an example of a reverse characteristic impulse response of the impulse response measured at the front position of the speaker, and an amplitude-frequency characteristic corresponding thereto;

FIGS. **8**A and **8**B are diagrams illustrating an example of an impulse response in a case where a correction process is performed by a filter that realizes a reverse characteristic impulse response at the front position of the speaker, and an amplitude-frequency characteristic corresponding thereto;

FIG. **9** is a diagram illustrating an impulse response measurement when a filter coefficient group is obtained in the audio signal processing unit to correct the speaker characteristic of the speaker in regard to a listening position;

FIG. **10** is a diagram illustrating a configuration of the audio system when the filter coefficient group is obtained in the audio signal processing unit to correct the speaker characteristic of the speaker in regard to the listening position;

FIGS. **11**A and **11**B are diagrams illustrating an example of an impulse response measured at the listening position, and an amplitude-frequency characteristic corresponding thereto;

FIG. **12** is a diagram illustrating an example of a reverse characteristic impulse response of the impulse response measured at the listening position, and an amplitude-frequency characteristic corresponding thereto;

FIGS. **13**A and **13**B are diagrams illustrating an example of an impulse response in a case where a correction process is performed by a filter that realizes a reverse characteristic impulse response at the listening position, and an amplitude-frequency characteristic corresponding thereto;

FIG. **14** is a block diagram illustrating a configuration example of a digital photo frame according to a second embodiment of the present disclosure;

FIG. **15** is a diagram illustrating an example of an installation state (installation position) of the digital photo frame;

FIG. **16** is a flowchart illustrating an example of a process sequence of a filter coefficient setting in regard to a control unit;

FIG. **17** is a block diagram illustrating a configuration example of a digital photo frame according to a third embodiment of the present disclosure;

FIGS. **18**A and **18**B are diagrams illustrating a horizontal displacement state and a vertical displacement state of the digital photo frame;

FIG. **19** is a flowchart illustrating an example of a process sequence of a filter coefficient setting in regard to a control unit;

FIG. **20** is a block diagram illustrating a configuration example of a television receiver according to a fourth embodiment of the present disclosure;

FIG. **21** is a diagram illustrating an exterior appearance of the television receiver and an impulse response measurement when a filter coefficient group is obtained in an audio signal processing unit to correct a speaker characteristic of a speaker in regard to a listening position;

FIG. **22** is a flowchart illustrating an example of a process sequence of a filter coefficient setting in regard to a control unit;

FIG. **23** is a diagram illustrating a configuration of an audio system when the filter coefficient group is obtained in the audio signal processing unit to correct the speaker characteristic of the speaker in regard to the listening position; and

FIG. **24** is a diagram illustrating an example of a listening position inside a vehicle.

DETAILED DESCRIPTION OF EMBODIMENTS

Hereinafter, embodiments of the present disclosure (hereinafter, referred to as "embodiments") will be described. In addition, the description will be made in the following order.

1. First Embodiment
2. Second Embodiment
3. Third Embodiment
4. Fourth Embodiment
5. Modification

1. First Embodiment

Configuration Example of Digital Photo Frame

FIG. **1** illustrates a configuration example of a digital photo frame **100** according to a first embodiment. The digital photo frame **100** includes a control unit **101**, a user operation unit **102**, an embedded memory **103**, an external memory interface **104**, a communication interface **105**, and a video and audio output section **106**, and the respective units are connected to each other through an internal bus **107**.

The control unit **101** controls each unit of the digital photo frame **100**. The control unit **101** includes a CPU, a ROM, a RAM, or the like. The ROM stores a CPU control program, or the like. The RAM is used for temporary storage of data necessary for a control process of the CPU. The CPU develops the program or data read-out from the ROM on the RAM and activates the program, and controls each unit of the digital photo frame **100**.

The user operation unit **102** makes up a user interface, and is connected to the control unit **101**. The user operation unit **102** includes, for example, keys, buttons, a dial, or the like, which is disposed in a housing plane (not shown) of the digital photo frame **100**. A user may perform a power on and off operation of the digital photo frame **100**, a reproduction start-up and stopping operating, or the like by using the user operation unit **102**.

The embedded memory **103** is a memory that includes, for example, a flash memory and retains a video signal (video file), an audio signal (music signal), or the like. The video signal and the audio signal are acquired from, for example, a memory card or the like through copying, or acquired over a network. The external memory interface **104** includes a memory card slot, a USB memory port, or the like. The communication interface **105** performs communication with an external apparatus over a network such as the Internet.

The video and audio output section **106** will be described. First, a video system will be described. The video and audio output section **106** includes an overlapping unit **111**, a panel driving unit **112**, and a display panel **113** as a video system. The panel driving unit **112** generates a panel driving signal that is necessary for displaying a video on the display panel **113** from a video signal SV supplied through the overlapping unit **111**. The panel driving signal generated in the panel driving unit **112** is transmitted to the display panel **113**, the display panel **113** is operated according to a panel driving signal, and thereby a video is displayed on the display panel **113**.

The display panel **113** displays a video based on the panel driving signal transmitted from the panel driving unit **112**. The display panel **113** is configured by, for example, an LCD (Liquid Crystal Display), but an organic EL (electro-luminescence) panel or the like may be used.

The overlapping unit **111** overlaps a display signal Sui for a GUI (Graphical User Interface) screen generated under a control of the control unit **101** on a video signal SV, and supplies the resultant overlapped signal to the panel driving unit **112**. In this manner, the display signal Sui is overlapped on the video signal SV, such that a user interface screen such as a menu display is displayed on the display panel **113** while being overlapped on a video.

FIG. **2** illustrates an exterior appearance of the digital photo frame **100**. This digital photo frame **100** has an overall rectangular shape, and is configured in such a manner that the display panel **113** is inserted in a rectangular-shaped frame **114**. A speaker **125** is provided in a rear surface as designated by a broken line. In addition, as the speaker **125**, two speakers for left-side audio and right-side audio are provided for stereo reproduction.

Returning to FIG. **1**, next, an audio system will be described. In addition, actually, two audio systems for left-side audio and right-side audio are provided, but the two audio systems are the same as each other, such that, here, only one audio system will be described. The video and audio output section **106** includes an audio signal processing unit (audio signal processing unit (A)) **121**, an audio signal processing unit (audio signal processing unit (B)) **122**, a D/A converter **123**, an amplifier **124**, and a speaker **125**, as the audio system.

The audio signal processing unit **121** makes up one side audio signal processing unit, and the audio signal processing unit **122** makes up the other side audio signal processing unit. In this embodiment, the audio signal processing unit **121** is located at a front stage, and the audio signal processing unit **122** is located at a subsequent stage, but this order may be reversed. The audio signal processing units **121** and **122** serially perform a processing with respect to the audio signal (music signal) SA as an input audio signal, and obtain an output audio signal for driving the speaker **125**.

The audio signal processing unit **121** performs a correction process with respect to the audio signal SA, by a filter that realizes a reverse characteristic of an impulse response that is measured at a front position of the speaker **125**. In addition, the audio signal processing unit **122** performs the correction process with respect to the audio signal SA by a filter that realizes a reverse characteristic of impulse response that is measured at a position different from the front position of the speaker **125**. Here, the position different from the front position of the speaker **125** includes a listening position of the digital photo frame **100**.

The audio signal processing units **121** and **122** include a digital filter, for example, an FIR (Finite Impulse Response) filter, an IR (Infinite impulse response) filter, or the like. FIG. **3** illustrates an example of the digital filter F used as the audio signal processing units **121** and **122**.

The digital filter F includes a plurality of delay blocks **11**, a plurality of multipliers **12**, and a plurality of adders **13**, respectively. A signal SigX input to the digital filter F is subject to a Z transformation (Laplace transformation with respect to a discrete signal) in each delay block **11**, and is delayed by one clock. The delayed signal is multiplied by a predetermined filter coefficient group h (a set of filter coefficients h**0** to hN) in each multiplier **12**. Each signal passed through each multiplier **12** is added to each other by each adder **13** and is output as an output signal SigY. The details of the filter coefficient group h of the digital filter F making up the audio signal processing units **121** and **122** will be described later.

The D/A converter **123** converts the audio signal obtained in the audio signal processing unit **122** from a digital signal to an analog signal. In addition, the amplifier **124** amplifies the analog audio signal obtained in the D/A converter **123**, and supplies the amplified signal to the speaker **125**. The speaker **125** outputs audio corresponding to the audio signal supplied from the amplifier **124**.

Determination of Filter Coefficient Group of Audio Signal Processing Unit

As described above, the audio signal processing unit **121** performs the correction process by the filter that realizes the reverse characteristic of the impulse response that is measured at the front position of the speaker **125**. That is, the filter coefficient group h of the digital filter F making up the audio signal processing unit **121** is determined as described below.

The determination of the filter coefficient group h is performed based on a measurement result of the impulse response measured at the front position of the speaker **125**. As shown in FIG. **4**, the measurement of the impulse response is performed by using the speaker **125** and a microphone **131** that is opposite to the speaker **125** at a predetermined distance. A measurement signal such as a TSP (Time Stretched Pulse) signal is supplied to the speaker **125**, and a sound emission from the speaker **125** is performed. This audio is measured by the microphone **131**, and thereby an impulse response is obtained. FIG. **5** illustrates a configuration of the audio system in this case. In this case, the measurement signal is converted from a digital signal to an analog signal in the D/A converter **123**, and is amplified in the amplifier **124**, and then is supplied to the speaker **125**.

FIG. **6**A illustrates an example of the impulse response measured by the microphone **131**. In FIG. **6**A, the horizontal axis represents a time, and the vertical axis represents amplitude. The impulse response shown in FIG. **6**A is subject to a Fourier transformation (time domain signal is transformed to a frequency domain signal), such that an amplitude-frequency characteristic as shown in FIG. **6**B may be obtained. In FIG. **6**B, the horizontal axis represents frequency and the vertical axis represents amplitude. The characteristic of the speaker **125** shown in FIGS. **6**A and **6**B is a speaker characteristic.

The filter coefficient group h of the digital filter F making up the audio signal processing unit **121** is determined in such a manner that the speaker characteristic of the speaker **125** shown in FIGS. **6**A and **6**B is corrected into an ideal speaker characteristic. The ideal speaker characteristic represents an impulse response that is to be collected by a microphone under the assumption that an ideal speaker and microphone are opposite to each other with the same distance as when the impulse response of the speaker **125** was measured, and a frequency characteristic thereof. Here, as the ideal speaker characteristic, an example where an impulse peak is sharp and the frequency characteristic is flat is exemplified, but this is not limited thereto and may be arbitrarily set.

The filter coefficient group h (h**0** to hN) of the digital filter F making up the audio signal processing unit **121** is regarded to realize a "reverse characteristic" that is calculated by excluding "1" in the speaker characteristic of the speaker **125**. FIG. **7**A illustrates an impulse response of the reverse characteristic and FIG. **7**B illustrates a frequency characteristic of the reverse characteristic. This impulse response of the reverse characteristic may be set as the filter coefficients h**0** to hN of the digital filter F. In addition, the number of the filter coefficients h**0** to hN (the number of taps) is the number of peaks of the impulse response.

The audio signal processing unit **121** performs the correction process with respect to the audio signal SA by digital filter F in which the filter coefficient group h is set as described above. In this manner, the reverse characteristic is applied to the audio signal SA, and is overlapped with the speaker characteristic when this audio signal SA is emitted through the speaker **125**. That is, the speaker characteristic of the speaker **125** is corrected. FIG. **8**A illustrates the impulse response of the speaker **125** in a case where the audio signal SA is subjected to the correction process, and FIG. **8**B illustrates the frequency characteristic thereof. As shown in FIGS. **8**A and **8**B, the peak of the impulse response becomes sharp and the frequency characteristic becomes flat.

That is, for example, in a case where an impulse response as shown in FIG. **6**A and a frequency characteristic as shown in FIG. **6**B are obtained by an impulse measurement at the front position of the speaker **25** as shown in FIG. **4**, when a reverse characteristic thereof is calculated, results as shown in FIGS. **7**A and **7**B are obtained. In a case where an impulse response of a reverse characteristic thereof is realized by the digital filter F in the audio signal processing unit **121**, when the speaker characteristic is measured at the same measurement point, it is possible to obtain a flat frequency characteristic as shown in FIG. **8**A and an impulse response close to an impulse response shown in FIG. **8**B.

As described above, the audio signal processing unit **122** performs the correction process by the filter that realizes the reverse characteristic of the impulse response measured at a location (listening position) different from the front position of the speaker **125**. That is, the filter coefficient group h of the digital filter F making up the audio signal processing unit **122** is determined as described below.

The determination of the filter coefficient group h is performed based on a measurement result of the impulse response measured at a position (listening position) different from the front position of the speaker **125**. As shown in FIG. **9**, the measurement of the impulse response is performed by using the speaker **125** and the microphone **131** at the listening position. In this case, even when the speaker characteristic of the speaker **125** is corrected by the above-described audio signal processing unit **121**, when a way in which a sound reaches the microphone **131** from the speaker **125** varies, the impulse response or frequency characteristic is disturbed due to an effect caused by diffraction or reflection of the sound.

A measurement signal such as a TSP (Time Stretched Pulse) signal is supplied to the speaker **125**, and is emitted from the speaker **125**. This audio is measured by using the microphone **131**, and an impulse response is obtained. FIG. **10** illustrates a configuration of an audio system of this case. In this case, the measurement signal is corrected in the audio signal processing unit **121**, and is converted from a digital signal to an analog signal in the D/A converter **123**, and is amplified in the amplifier **124**, and then is supplied to the speaker **125**.

FIG. **11**A illustrates an example of the impulse response measured by the microphone **131**. In FIG. **11**A, the horizontal axis represents time, and the vertical axis represents amplitude. The impulse response shown in FIG. **11**A is subject to a Fourier transformation (time domain signal is transformed to a frequency domain signal), such that an amplitude-frequency characteristic as shown in FIG. **11**B may be obtained. In FIG. **11**B, the horizontal axis represents frequency and the vertical axis represents amplitude. The characteristic of the speaker **125** shown in FIGS. **11**A and **11**B is a speaker characteristic.

The filter coefficient group h of the digital filter F making up the audio signal processing unit **122** is determined in such a manner that the speaker characteristic of the speaker **125** shown in FIGS. **11**A and **11**B at a listening position is corrected into an ideal speaker characteristic at the listening position. The ideal speaker characteristic represents an impulse response that is to be collected by a microphone under the assumption that the ideal speaker and microphone are opposite to each other with the same distance as when the impulse response of the speaker **125** was measured at the listening position, and a frequency characteristic thereof. Here, as the ideal speaker characteristic, an example where an impulse peak is sharp and the frequency characteristic is flat is exemplified, but this is not limited thereto and may be arbitrarily set.

The filter coefficient group h (h**0** to hN) of the digital filter F making up the audio signal processing unit **122** is regarded to realize the "reverse characteristic" that is calculated by excluding "1" in the speaker characteristic of the speaker **125**. FIG. **12**A illustrates an impulse response of the reverse characteristic and FIG. **12**B illustrates a frequency characteristic of the reverse characteristic. This impulse response of the reverse characteristic may be set as the filter coefficients h**0** to hN of the digital filter F. In addition, the number of the filter coefficients h**0** to hN (the number of taps) is the number of peaks of the impulse response.

The audio signal processing unit **122** performs the correction process with respect to the audio signal SA by a digital filter F in which the filter coefficient group h is set as described above. In this manner, the reverse characteristic is applied to the audio signal SA, and is overlapped with the speaker characteristic when this audio signal SA is emitted through the speaker **125**. That is, the speaker characteristic of the speaker **125** at the listening position is corrected. FIG. **13**A illustrates the impulse response of the speaker **125** in a case where the audio signal is subjected to the correction process, and FIG. **13**B illustrates the frequency characteristic thereof. As shown in FIGS. **13**A and **13**B, the peak of the impulse response becomes sharp and the frequency characteristic becomes flat.

That is, it is assumed that when the speaker inverse filtering process is performed by the audio signal processing unit **121**, for example, in regard to an impulse measurement at a listening position (listening point) as shown in FIG. **9**, an impulse response and a frequency characteristic as shown in FIGS. **11**A and **11**B are obtained. In this case, when a reverse characteristic thereof is calculated, results as shown in FIGS. **12**A and **12**B are obtained. In a case where an impulse response of a reverse characteristic thereof is realized by the digital filter F in the audio signal processing unit **122**, when the speaker characteristic is measured at the same measurement point, it is possible to obtain a flat frequency characteristic as shown in FIG. **13**A and an impulse response close to an impulse response shown in FIG. **13**B.

An operation of the audio system in the video and audio output section **106** of the digital photo frame **100** shown in FIG. **1**. When audio such as a BGM is output, an audio signal SA is supplied to the audio signal processing unit **121**. In the audio signal processing unit **121**, a correction process is performed the audio signal SA by a filter that realizes a reverse characteristic of an impulse response measured at the front position of the speaker **125**. In this manner, the reverse characteristic is applied to the audio signal SA, and is overlapped with the speaker characteristic when this audio signal SA is emitted through the speaker **125**. That is, the speaker characteristic of the speaker **125** is corrected.

The output audio signal of the audio signal processing unit **121** is supplied to the audio signal processing unit **122**. In the audio signal processing unit **122**, a correction process is performed with respect to the audio signal SA by a filter that realizes the reverse characteristic of the impulse response measured at a position (listening position) different from the front position of the speaker **125**. In this manner, the reverse characteristic is applied to the audio signal SA, and is overlapped with the speaker characteristic when this audio signal is emitted through the speaker **125**. That is, the speaker characteristic of the speaker **125** at the listening position is corrected.

An output audio signal of the audio signal processing unit **121** is supplied to the D/A converter **123** and is converted from a digital signal to an analog signal. The analog audio signal output from the D/A converter **123** is amplified in the amplifier **124**, and then is supplied to the speaker **125**. From the speaker **125**, audio corresponding to the audio signal is output.

As described above, in regard to the digital photo frame **100** shown in FIG. **1**, in the audio system of the video and audio output section **106**, through the correction process of the audio signal processing unit **121**, it is possible to correct disturbance in an inherent sound pressure-frequency characteristic or a phase characteristic which the speaker **125** has. In addition, in this audio system, through the correction process of the audio signal processing unit **122**, it is possible to correct disturbance in a sound pressure-frequency characteristic or a phase characteristic, which are caused due to a fact that the listening position (listening point) becomes different from the front position of the speaker **125**. Therefore, even when the speaker **125** is not disposed in the front direction, it is possible to realize high acoustic quality. That is, an excellent localization of sound and acoustic quality may be realized.

2. Second Embodiment

Configuration Example of Digital Photo Frame

FIG. **14** illustrates a configuration example of a digital photo frame **100**A according to a second embodiment. In FIG. **14**, like reference numerals will be given to like parts corresponding to FIG. **1**, and detailed description thereof will not be repeated. This digital photo frame **100**A includes a control unit **101**A, a user operation unit **102**, an embedded memory **103**, an external memory interface **104**, a communication interface **105**, and a video and audio output section **106**, and the respective units are connected to each other through an internal bus **107**.

The video and audio output section **106** includes an overlapping unit **111**, a panel driving unit **112**, and a display panel **113** as a video system. In addition, the video and audio output section **106** includes an audio signal processing unit (audio signal processing unit (A)) **121**, an audio signal processing unit (audio signal processing unit (B)) **122**A, a D/A converter **123**, an amplifier **124**, and a speaker **125** as an audio system.

The audio signal processing unit **122**A of the audio system of the video and audio output section **106** corresponds to the audio signal processing unit **122** of the audio system of the video and audio output section **106** in the digital photo frame **100** shown in FIG. **1**. Similarly to the audio signal processing unit **122**, the audio signal processing unit **122**A performs a correction process with respect to an audio signal SA by a filter that realizes a reverse characteristic of an impulse response measured at a position (listening position) different from the front position of the speaker **125**.

The filter coefficient group h set to the digital filter F of the audio signal processing unit **122** is fixed. Contrary to this, in the audio signal processing unit **122**A, the setting of the filter coefficient group h of a digital filter F can be changed. This change in the setting of the filter coefficient group h of the digital filter F in the audio signal processing unit **122**A is performed based on a selection operation of the filter coefficient group h by a user under the control of the control unit **101**A. In this case, the control unit **101**A makes up a filter coefficient group setting unit.

The control unit **101**A corresponds to the control unit **101** of the digital photo frame **100** shown in FIG. **1**, and includes a CPU, a ROM, a RAM, or the like and controls each unit of the digital photo frame **100**A, similarly to the control unit **101**. The control unit **101**A includes a retaining unit **101***a*. This retaining unit **101***a* retains a plurality of filter coefficient groups h corresponding to an installation state of the digital photo frame **100**A, that is an installation state of the speaker **125** as a filter coefficient group h that is set to the digital filter F of the audio signal processing unit **122**A. The retaining unit **101***a* makes up a filter coefficient group retaining unit.

FIG. **15** illustrates an example of the installation state of the digital photo frame **100**A. The retaining unit **101***h* retains the filter coefficient group h according to each installation state such as “wall-hanging”, “living room table (close to wall)”, “living room table (center)”, “bed side”, and “entrance hall”. Disturbance in the sound pressure-frequency characteristic or the phase characteristic at the listening position varies depending on the installation state of the speaker. The filter coefficient group h related to each installation state is determined by performing an impulse measurement at the listening position, similarly to the filter coefficient group h of the digital filter F in the audio signal processing unit **122** shown in FIG. **1**.

A flowchart of FIG. **16** illustrates an example of a process sequence in the filter coefficient setting in the control unit **101**A. In step ST**1**, the control unit **101**A starts a process, and then moves to a process in step ST**2**. In step ST**2**, the control unit **101**A displays a selection menu as shown in FIG. **15** on a display panel **113** for a selection operation of the filter coefficient group h by a user. In this case, the control unit **101**A generates a display signal Sui of the selection menu. In addition, FIG. **15** illustrates a state where the filter coefficient group h of the “living room table (center) is selected.”

Next, in step ST**3**, when a user selects a desired filter coefficient group h, in step ST**4**, the control unit **101**A fetches the filter coefficient group h from the retaining unit **101***a*, and sets it to the digital filter F of the audio signal processing unit **122**A. Then, in step ST**5**, the control unit **101**A terminates the process.

Detailed description will not be repeated, but other configurations of the digital photo frame **100**A shown in FIG. **14** are substantially the same as those of the digital photo frame **100** shown in FIG. **1** and operate in the same way.

As described above, in the digital photo frame **100**A shown in FIG. **14**, the disturbance in the sound pressure-frequency characteristic or the phase characteristic due to a difference in the listening position from the front position of the speaker **125** is corrected through the correction process in the audio signal processing unit **122**A. Therefore, as is the case with the digital photo frame **100** shown in FIG. **1**, even when the speaker **125** is not disposed in the front direction, it is possible to realize high acoustic quality.

In addition, in the digital photo frame **100**A shown in FIG. **14**, the setting of the filter coefficient group h of the digital filter F in the audio signal processing unit **122**A can be changed. Therefore, the setting of the filter coefficient group h of the digital filter F in the audio signal processing unit **122**A can be changed to a filter coefficient group h corresponding to the installation state of the digital photo frame **100**A, that is, the installation state of the speaker **125**. Therefore, it is possible to realize high acoustic quality regardless of the installation state of the digital photo frame **100**A, that is, the installation of the speaker **125**.

In addition, in regard to the digital photo frame **100**A shown in FIG. **14**, when the setting of the filter coefficient group h of the digital filter F in the audio signal processing unit **122**A is changed, the selection menu is displayed on the display panel **113** (refer to FIG. **15**). Therefore, a user may easily select the filter coefficient group h corresponding to the installation state of the digital photo frame **100**A, that is, the installation state of the speaker **125**.

3. Third Embodiment

Configuration Example of Digital Photo Frame

FIG. **17** illustrates a configuration example of a digital photo frame **100**B according to a third embodiment. In FIG. **17**, like reference numerals will be given to like parts corresponding to FIG. **1**, and detailed description thereof will not be repeated. This digital photo frame **100**B includes a control unit **101**B, a user operation unit **102**, an embedded memory **103**, an external memory interface **104**, a communication interface **105**, and a video and audio output section **106**, and the respective units are connected to each other through an internal bus **107**.

The video and audio output section **106** includes an overlapping unit **111**, a panel driving unit **112**, and a display panel **113** as a video system. In addition, the video and audio output section **106** includes an audio signal processing unit (audio signal processing unit (A)) **121**, an audio signal processing unit (audio signal processing unit (B)) **122**B, a D/A converter **123**, an amplifier **124**, and a speaker **125** as an audio system.

The audio signal processing unit **122**B of the audio system of the video and audio output section **106** corresponds to the audio signal processing unit **122** of the audio system of the video and audio output section **106** in the digital photo frame **100** shown in FIG. **1**. Similarly to the audio signal processing unit **122**, the audio signal processing unit **122**B performs a correction process with respect to an audio signal SA by a filter that realizes a reverse characteristic of an impulse response measured at a position (listening position) different from the front position of the speaker **125**.

The filter coefficient group h set to the digital filter F of the audio signal processing unit **122** is fixed. Contrary to this, in the audio signal processing unit **122**B, the setting of the filter coefficient group h of a digital filter F can be changed. This change in the setting of the filter coefficient group h of the digital filter F in the audio signal processing unit **122**B is performed based on an installation angle of the digital photo frame **100**B, that is, an installation angle of the display panel **113**. More specifically, this setting is changed based on whether the digital photo frame **100**B is disposed with a horizontal displacement or a vertical displacement under a control of the control unit **101**B. In this case, the control unit **101**B makes up a filter coefficient group setting unit. FIG. **18**A illustrates a state where the digital photo frame **100**B is disposed with the horizontal displacement, and FIG. **18**B illustrates a state where the digital photo frame **100**B is disposed with the vertical displacement.

The control unit **101**B corresponds to the control unit **101** of the digital photo frame **100** shown in FIG. **1**, and includes a CPU, a ROM, a RAM, or the like and controls each unit of the digital photo frame **100**B, similarly to the control unit **101**. The control unit **101**B includes a retaining unit **101***b*. This retaining unit **101***b* retains a filter coefficient group h corresponding to the horizontal displacement and the vertical displacement of the digital photo frame **100**B as a filter coefficient group h that is set to the digital filter F of the audio signal processing unit **122**B. The retaining unit **101***b* makes up a filter coefficient group retaining unit.

A sensor **141** detects whether the digital photo frame **100**B is disposed with the horizontal displacement or the vertical displacement, and this detection output is transmitted to the control unit **101**B. The sensor **141** includes, for example, an angular velocity sensor such as a gyro sensor, a gravitational acceleration sensor, or a magnetic sensor. This sensor **141** makes up an installation angle detecting unit.

Disturbance in the sound pressure-frequency characteristic or phase characteristic in the listening position varies depending on the installation angle (the horizontal displacement and the vertical displacement) of the digital photo frame **100**B, that is, the installation angle of the display panel **113**. The filter coefficient group h corresponding to the horizontal displacement and the vertical displacement is determined by performing an impulse measurement at the listening position with respect to each installation angle, similarly to the filter coefficient group h of the digital filter F in the audio signal processing unit **122** shown in FIG. **1**.

A flowchart of FIG. **19** illustrates an example of a process sequence in the filter coefficient setting in the control unit **101**B. In step ST**11**, the control unit **101**B starts a process, and then moves to a process in step ST**12**. In step ST**12**, the control unit **101**B determines whether the digital photo frame **100**B is with the horizontal displacement or the vertical displacement based on a detection output of the sensor **141**.

Next, in step ST**13**, the control unit **101**B selects the filter coefficient group h of either the horizontal displacement or the vertical displacement based on the determination in step ST**12**. Then, in step ST**14**, the control unit **101**B selectively fetches the filter coefficient group h selected in step ST**13** from the retaining unit **101**, and sets it to the digital filter F of the audio signal processing unit **122**B. Then, in step ST**15**, the control unit **101**B terminates the process.

Detailed description will not be repeated, but other configurations of the digital photo frame **100**B shown in FIG. **17** are substantially the same as those of the digital photo frame **100** shown in FIG. **1** and operate in the same way.

As described above, in the digital photo frame **100**B shown in FIG. **17**, the disturbance in the sound pressure-frequency characteristic or the phase characteristic due to a difference in the listening position from the front position of the speaker **125** is corrected through the correction process in the audio signal processing unit **122**B, similarly to the digital photo frame **100** shown in FIG. **1**. Therefore, as is the case with the digital photo frame **100** shown in FIG. **1**, even when the speaker **125** is not disposed in the front direction, it is possible to realize high acoustic quality.

In addition, in the digital photo frame **100**B shown in FIG. **17**, the setting of the filter coefficient group h of the digital filter F in the audio signal processing unit **122**B can be changed. The filter coefficient group h of the digital filter F in the audio signal processing unit **122**B is changed to a filter coefficient group h corresponding to the installation angle (the horizontal displacement or the vertical displacement) of the digital photo frame **100**B based on the detection output of the sensor **141**. Therefore, it is possible to realize high acoustic quality regardless of whether the digital photo frame **100**B, that is, the display panel **113** is displace with the vertical displacement or the horizontal displacement.

4. Fourth Embodiment

Configuration Example of Television Receiver

FIG. **20** illustrates a configuration example of a television receiver **200** according to a fourth embodiment. The television receiver **200** includes a control unit **201**, a user operation unit **202**, an HDD (Hard Disk Drive) **203**, a microphone input interface **204**, a microphone **205**, and a video and audio output section **206**, and the respective units are connected to each other through an internal bus **207**.

The control unit **201** controls each unit of the television receiver **200**. The control unit **201** includes a CPU, a ROM, a RAM, or the like. The ROM stores a control program of the CPU, or the like. The RAM is used for temporary storage of data necessary for a control process of the CPU. The CPU develops the program or data read-out from the ROM on the RAM and activates the program, and controls each unit of the television receiver **200**.

The user operation unit **202** makes up a user interface, and is connected to the control unit **201**. The user operation unit **202** includes, for example, keys, buttons, a dial, or the like, which is disposed in a housing plane (not shown) of the television receiver **200**, a transmitting and receiving device of a remote controller, a touch panel disposed on a display panel, or the like. A user may perform a power on and off operation of the television receiver **200**, a channel selecting operation, or the like by using the user operation unit **202**.

The HDD **203** performs a recording and a reproduction of a video signal. The microphone input interface **204** performs an input of an audio signal collected in the microphone **205**. In addition, as a connection type between the microphone interface **204** and the microphone **205**, a wireless connection may be considered, in addition to a wired connection through a cable as shown in the drawing.

The video and audio output section **206** will be described. The video and audio output section **206** includes a digital tuner **211**, an overlapping unit **212**, a panel driving unit **213**, and a display panel **214**. In addition, the video and audio output section **206** includes an audio signal processing unit (audio signal processing unit (A)) **215**, an audio signal processing unit (audio signal processing unit (B)) **216**, a D/A converter **217**, an amplifier **218**, and a speaker **219**.

The digital tuner **211** processes a television broadcasting signal received by a reception antenna (not shown), and outputs a video signal SV and an audio signal SA corresponding to a user's channel selection. The panel driving unit **213** generates a panel driving signal that is necessary for displaying a video on the display panel **214** from the video signal SV supplied through the overlapping unit **212**. The panel driving signal generated in the panel driving unit **213** is transmitted to the display panel **214**, and the display panel **214** operates correspondingly to the panel driving signal, and thereby the received video is displayed on the display panel **214**.

The display panel **214** displays the video based on the panel driving signal transmitted from the panel driving unit **213**. The display panel **214** includes, for example, an LCD (Liquid Crystal Display), a PDP (Plasma Display Panel), or an organic El (electro-luminescence) panel, or the like.

The overlapping unit **212** overlaps a display signal Sui for a GUI (Graphical User Interface) screen generated under a control of the control unit **201** on a video signal SV, and supplies the resultant overlapped signal to the panel driving unit **213**. In this manner, the display signal Sui is overlapped on the video signal SV, such that a user interface screen such as a menu display and a program table is displayed on the display panel **214** while being overlapped on a video.

FIG. **21** illustrates an exterior appearance of the television receiver **200**. This television receiver **200** has an overall rectangular shape, and is configured in such a manner that the display panel **214** is inserted in a rectangular-shaped housing **220**. A speaker **219** is provided in a rear surface as designated by a broken line. In addition, as the speaker **219**, two speakers for left-side audio and right-side audio are provided to realize a stereo reproduction.

Returning to FIG. **1**, next, an audio system of the video and audio output section **206** will be described. In addition, actually, two audio systems for left-side audio and right-side audio are provided, but two audio systems are the same as each other, such that, here, only one audio system will be described.

The audio signal processing unit **215** makes up one side audio signal processing unit, and the audio signal processing unit **216** makes up the other side audio signal processing unit. In this embodiment, the audio signal processing unit **215** is located at a front stage, the audio signal processing unit **216** is located at a subsequent state, and this order may be reversed. The audio signal processing units **215** and **216** serially perform a processing with respect to the audio signal (input audio signal) SA that can be obtained by the digital tuner **211**, and obtain an output audio signal for driving the speaker **219**.

The audio signal processing unit **215** corresponds to the audio signal processing unit **121** of the digital photo frame **100** shown in FIG. **1**, and performs a correction process with respect to the audio signal SA, by a filter that realizes a reverse characteristic of an impulse response that is measured at a front position of the speaker **219**. A filter coefficient group h of the digital filter F of the audio signal processing unit **215** is determined by performing an impulse measurement at the front position of the speaker **219** similarly to the filter coefficient group h of the digital filter F of the audio signal processing unit **122**.

The audio signal processing unit **216** corresponds to the audio signal processing unit **122** of the digital photo frame **100** shown in FIG. **1**. Similarly to the audio signal processing unit **122**, the audio signal processing unit **216** performs a correction process with respect to the audio signal SA by a filter that realizes a reverse characteristic of the impulse response measured at a position (listening position) different from the front position of the speaker **125**.

The filter coefficient group h set to the digital filter F of the audio signal processing unit **122** is fixed. Contrary to this, in the audio signal processing unit **216**, the setting of the filter coefficient group h of a digital filter F can be changed. This setting of the filter coefficient group h is performed under the control of the control unit **201**, but the details thereof will be described.

The D/A converter **217** converts the audio signal obtained in the audio signal processing unit **216** from a digital signal to an analog signal. In addition, the amplifier **218** amplifies the analog audio signal obtained in the D/A converter **217**, and supplies the amplified signal to the speaker **219**. The speaker **219** outputs audio corresponding to the audio signal supplied from the amplifier **218**.

An operation of the television receiver **200** shown in FIG. **20** will be described. A television broadcasting signal received by a reception antenna (not shown) is supplied to the digital tuner **211**. In this digital tuner **211**, the television broadcasting signal is processed, and a video signal SV and an audio signal SA corresponding to a user's channel selection are output. The video signal SV output from the digital tuner **211** is supplied to the panel driving unit **213** through the overlapping unit **212**.

In the panel driving unit **213**, a panel driving signal that is necessary for displaying a video on the display panel **214** is generated from the video signal SV. This panel driving signal is transmitted to the display panel **214**. In this manner, a received video is displayed on the display panel **214**. In addition, a display signal Sui for a GUI screen is generated at an appropriate timing under a control of the control unit **201**. This display signal Sui is supplied to the overlapping unit **212**, and is overlapped on the video signal SV. In this manner, a user interface screen such as a menu display and a program table is displayed on the display panel **214** while being overlapped on a video.

In addition, the audio signal SA output from the digital tuner **211** is supplied to the audio signal processing unit **215**. In this audio signal processing unit **215**, a correction process is performed with respect to the audio signal SA by a filter that realizes a reverse characteristic of the impulse response measured at the front position of the speaker **219**. In this manner, the reverse characteristic is applied to the audio signal SA, and is overlapped with the speaker characteristic when the audio signal SA is emitted through the speaker **219**. That is, the speaker characteristic of the speaker **219** is corrected.

The output audio signal of the audio signal processing unit **215** is supplied to the audio signal processing unit **216**. In the audio signal processing unit **216**, a correction process is performed with respect to the audio signal SA by a filter that realizes the reverse characteristic of the impulse response measured at a position (listening position) different from the front position of the speaker **219**. In this manner, the reverse characteristic is applied to audio signal SA and is overlapped with the speaker characteristic when this audio signal SA is emitted through the speaker **219**. That is, the speaker characteristic of the speaker **219** at the listening position is corrected.

An output audio signal of the audio signal processing unit **216** is supplied to the D/A converter **217** and is converted from a digital signal to an analog signal. The analog audio signal output from the D/A converter **217** is amplified in the amplifier **218**, and then is supplied to the speaker **219**. From the speaker **219**, a received audio, which corresponds to the received video that is displayed on the display panel **214**, is output.

Next, a setting process of filter coefficient group h in the digital filter F of the audio signal processing unit **216** will be described. The flowchart of FIG. **22** illustrates an example of a process sequence of the setting of the filter coefficient in the control unit **201**. In step ST**21**, the control unit **201** starts a process, and then moves to a process in step ST**22**. In step ST**22**, the control unit **201** performs a measurement of the impulse response.

In this case, a configuration of audio system is set as a configuration shown in FIG. **23**, and the control unit **201** supplies a measurement signal such as TSP (Time Stretched Pulse) signal to the speaker **219** and allows this signal to be emitted from the speaker **219**. Then, this emitted audio is measured by the microphone **205**, and an impulse response is obtained. In this case, as shown in FIG. **21**, the microphone **205** is placed at the listening position, and in this regard, the microphone **205** makes up an impulse response measuring unit.

Next, in step ST**23**, the control unit **201** calculates the filter coefficient group h that is to be set to the digital filter F of the audio signal processing unit **216** based on the impulse response measured in step ST**22**. In this case, the control unit **201** calculates a reverse characteristic of the impulse response, and obtains the filter coefficient group h (filter coefficients h**0** to hN) from this impulse response of the reverse characteristic. Then, in step ST**24**, the control unit **201** sets the filter coefficient group h calculated in step ST**23** to the digital filter F of the audio signal processing unit **216**. In this regard, the control unit **201** makes up a filter coefficient group calculating unit and a filter coefficient setting unit. Then, in step ST**25**, the control unit **201** terminates the process.

As described above, in regard to the television receiver **200** shown in FIG. **20**, in the audio system of the video and audio output section **206**, disturbance in an inherent sound pressure-frequency characteristic or a phase characteristic which the speaker **219** has is corrected through the correction process of the audio signal processing unit **215**. In addition, in this audio system, through the correction process of the audio signal processing unit **216**, it is possible to correct disturbance in a sound pressure-frequency characteristic or a phase characteristic, which are caused due to a fact that the listening position (listening point) becomes different from the front position of the speaker **219**. Therefore, even when the speaker **219** is not disposed in the front direction, it is possible to provide high acoustic quality. That is, an excellent localization of sound and an acoustic quality may be realized.

In addition, in the television receiver **200** shown in FIG. **20**, the setting of the filter coefficient group h of the digital filter F in the audio signal processing unit **216** can be changed. An impulse response at the listening position is measured by the microphone **205**, a filter coefficient group h that realizes a reverse characteristic of the impulse response is calculated, and is set to the digital filter F of the audio signal processing unit **216**. Therefore, disturbance in a sound pressure-frequency characteristic or a phase characteristic at the listening position can be reliably corrected. That is, as a filter coefficient group h of the digital filter F in the audio signal processing unit **216**, one that is compatible with a use environment can be set and high acoustic quality can be realized regardless of an actual use environment of a user.

5. Modification

Modification 1

In addition, in the above-described second embodiment, the digital photo frame **100**A is illustrated, and the plurality filter coefficient groups h that is retained in the retaining unit **101***a* corresponds to the installation state of the speaker such as "wall-hanging", "living room table (close to wall)", or the like. As the installation position state of the speaker, an installation angle state other than the installation position state may be included. Installation angle information includes, for example, a state such as a horizontal displacement and a vertical displacement.

Modification 2

In addition, the above-described second embodiment is applied to the digital photo frame **100**A, but it may be considered that the same configuration is applied to, for example, an in-vehicle audio reproducing system (car audio system). That is, it may be considered that a plurality of filter coefficient groups h corresponding to an in-vehicle listening position is retained, and it is possible to arbitrarily change a filter coefficient group h of a digital filter in an audio signal processing unit that corrects a speaker characteristic of a speaker at the listening position.

FIG. **24** illustrates an example of the listening position in the vehicle. In this case, a filter coefficient group retaining unit retains the filter coefficient group h corresponding to each listening position such as "driver's seat", "front passenger seat", and "back seat". Disturbance in a sound pressure-frequency characteristic or a phase characteristic at the listening position varies depending on the listening position. The filter coefficient group h at each listening position is determined by performing an impulse measurement regard to the listening position at each listening position, similarly to the filter coefficient group h of the digital filter F in the audio signal processing unit **122** described in FIG. **1**.

Modification 3

In addition, the above-described third embodiment is applied to the digital photo frame **100**B, but it may be considered that the same configuration is applied to, for example, a video camera. That is, it may be applied to a case where a speaker is integrally provided to a display panel portion of the video camera, and a plurality of aperture angles of the display panel with respect to a video camera main body is present. In this case, the aperture angle of the display panel is detected by a sensor, and as a filter coefficient group h of the digital filter in the audio signal processing unit that corrects a speaker characteristic of the speaker at a listening position, a filter coefficient group h corresponding to the aperture angle is automatically set.

Others

In addition, the above-described embodiments are illustrated to be applied to the digital photo frame or the television receiver. However, in addition to these apparatus, the embodiments of the present disclosure may be similarly applied to an apparatus (product) accompanied with another audio reproduction, for example, a video camera, a tablet PC, a mobile phone, a digital camera, a notebook PC, a portable gaming machine, a car audio, a dock type speaker, or the like.

In addition, in the above-described embodiments, the audio signal processing unit that corrects the speaker characteristic of the speaker, and the audio signal processing unit that corrects the speaker characteristic of the speaker at the listening position may be configured by software in addition to hardware. That is, it may be considered that these correction processes are performed by the software (program) using a computer.

The present disclosure contains subject matter related to that disclosed in Japanese Priority Patent Application JP 2010-244834 filed in the Japan Patent Office on Oct. 29, 2010, the entire contents of which are hereby incorporated by reference.

It should be understood by those skilled in the art that various modifications, combinations, sub-combinations and alterations may occur depending on design requirements and other factors insofar as they are within the scope of the appended claims or the equivalents thereof.

What is claimed is:

1. An audio signal processing device comprising:

two audio signal processing units that serially perform a processing with respect to an input audio signal, and obtain an output audio signal for driving a speaker,

wherein one audio signal processing unit of the two audio signal processing units performs, with respect to the input audio signal, a correction process through a filter that realizes a reverse characteristic of an impulse response measured at a first measurement position that is a front position of the speaker, and

the other audio signal processing unit performs, with respect to the input audio signal, a correction process through a filter that realizes a reverse characteristic of an impulse response measured at a second measurement position different from the first measurement position that is a front position of the speaker.

2. The audio signal processing device according to claim 1, further comprising:

a filter coefficient group retaining unit that retains a plurality of filter coefficient groups as a filter coefficient group of the filter of the other audio signal processing unit;

a filter coefficient group selecting unit that selects an arbitrary filter coefficient group among the plurality of filter coefficient groups retained in the filter coefficient group retaining unit; and

a filter coefficient setting unit that sets the filter coefficient group selected in the filter coefficient group selecting unit to the filter of the other audio signal processing unit.

3. The audio signal processing device according to claim 2, wherein the plurality of filter coefficient groups retained in the filter coefficient group retaining unit is a plurality of filter coefficient groups corresponding to an installation state of the speaker.

4. The audio signal processing device according to claim 2, wherein the plurality of filter coefficient groups retained in the filter coefficient group retaining unit is a plurality of filter coefficient groups corresponding to a listening position.

5. The audio signal processing device according to claim 1, wherein the speaker is disposed integrally with a display panel that performs a video display, and

the audio signal processing device further comprises:

a filter coefficient group retaining unit that retains a plurality of filter coefficient groups corresponding to an installation angle of the display panel as the filter coefficient group of the other audio signal processing unit;

an installation angle detecting unit that detects the installation angle of the display panel; and

a filter coefficient setting unit that fetches the filter coefficient group corresponding to the installation angle of the display panel from the plurality of filter coefficient groups that is retained in the filter coefficient group retaining unit, based on a detection output of the installation angle detecting unit, and sets the fetched filter coefficient group to the filter of the other audio signal processing unit.

6. The audio signal processing device according to claim 5, wherein as the installation angle of the display panel, there are two installation angles in a case where the display panel is disposed with a horizontal displacement and in a case where the display panel is disposed with a vertical displacement.

7. The audio signal processing device according to claim 1, further comprising:

an impulse response measuring unit that measures the impulse response at the second measurement position;

a filter coefficient group calculating unit that calculates the filter coefficient group of the filter that realizes a reverse characteristic of the impulse response measured in the impulse response measuring unit; and

a filter coefficient setting unit that sets the filter coefficient group calculated in the filter coefficient group calculating unit to the filter of the other audio signal processing unit.

8. The audio signal processing device according to claim 1, wherein the one audio signal processing unit performs the correction process to correct disturbance at an inherent sound pressure-frequency characteristic or a phase characteristic of the speaker.

9. The audio signal processing device according to claim 8, wherein the other audio signal processing unit performs the correction process to correct disturbance in a sound pressure-frequency characteristic or a phase characteristic caused by variation between a listening position of a user and the front position of the speaker.

10. The audio signal processing device according to claim 1,

wherein the other audio signal processing unit performs the correction process to correct disturbance in a sound pressure-frequency characteristic or a phase characteristic caused by variation between a listening position of a user and the front position of the speaker.

11. An audio signal processing method, comprising:

two audio signal processing steps of serially performing a processing with respect to an input audio signal and obtaining an output audio signal for driving a speaker,

wherein in one audio signal processing step of the two audio signal processing steps, a correction process is performed with respect to the input audio signal through a filter that realizes a reverse characteristic of an impulse response measured at a first measurement position that is a front position of the speaker, and

in the other audio signal processing step, a correction process is performed with respect to the input audio signal through a filter that realizes a reverse characteristic of an impulse response measured at a second measurement position different from the first measurement position that is a front position of the speaker.

12. A non-transitory computer-readable medium having embodied thereon a program, which when executed by a computer allows the computer to function as two audio signal processing units that serially perform a processing with respect to an input audio signal and obtain an output audio signal for driving a speaker,

wherein one audio signal processing unit of the two audio signal processing units performs, with respect to the input audio signal, a correction process through a filter that realizes a reverse characteristic of an impulse response measured at a first measurement position that is a front position of the speaker, and

the other audio signal processing unit performs, with respect to the input audio signal, a correction process through a filter that realizes a reverse characteristic of an impulse response measured at a second measurement position different from the first measurement position that is a front position of the speaker.

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